

WHAT INFLUENCES THE RISE AND FALL OF HEALTH RESEARCH DISCIPLINES?

*Insights from a mixed-method investigation of
occupational epidemiological research in the UK*

By

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DEDICATION

I dedicate this work to my mother for her constant, unconditional love, encouragement, and support.

Dedication is also extended to my gorgeous children; Anas, Ahmed, Islam, and Yassmeen, who continue to be my greatest source of joy and inspiration. I love you dearly and I look forward to watching you grow and continue to excel at everything you do.

Finally, I dedicate this thesis to the loving memory of my father, Mohammed Sweity (1925-1994), and my brother Shareef Sweity (1952-2013).

ABSTRACT

Introduction

Occupational Epidemiology (OE) has played a vital role in producing improvements in the working population's health. Nonetheless, anecdotal evidence indicates that OE in the UK is facing many challenges and the research workforce, funding, and output in this area are declining. This study aims to: investigate the nature and evolution of these key contributors to success; identify the external social, political, economic and any other factors which frame and contextualise these challenges and the facilitators; use this contextualisation to explain and evaluate how and why the identified challenges and facilitators influenced the OE field development compared to other similar fields; and explore how far they may explain the ebb and flow of research activity in OE in comparison with other health disciplines.

Methods

A sequential, mixed-method approach was undertaken in four phases. These included interviews with key UK-based OE researchers; a survey of UK-based OE researchers to test out themes that emerged from the first phase; a bibliometric analysis comparing trends and characteristics of UK-based OE published studies with those in public health epidemiology (PHE); and a documentary review of annual reports of three health research funding bodies including: the Medical Research Council, the Cancer Research Campaign, and the Health and Safety Commission.

Results

The lack of human and financial resources was found to be of utmost concern to the OE community, which increased over time and negatively affected researchers' abilities to conduct further and higher quality studies. The bibliometric study revealed that the number of PHE publications and researchers increased substantially while the numbers for OE remained fairly constant. Furthermore, it was found that in PHE much higher levels of collaboration and adoption of newer methods such as the use of molecular and genetic techniques were applied. Widening research collaboration and the adoption of newer methods were encouraged by funding bodies because both are perceived to contribute to research efficiency and commercialisation of research ideas. These have been adopted more widely by other fields, thus helping them to develop and improve their status, which was not the case for OE. Furthermore, fewer influential representatives from the field of OE were found within funding bodies, which had played a major role in directing resources to research within health fields and hence influencing their development.

Conclusions

Social, economic, and political factors such as the exclusion of occupational health (OH) from the National Health Service, deindustrialisation, and neoliberal government policies within public and higher education institutions particularly that focus on economic contribution of science, and research auditing and efficiency, most likely, have the greatest influence on funding decisions of research in OH and other health disciplines. These issues have significantly instigated obscurity of OH and hence OE within the agendas of both the government and the

funding bodies. Henceforward, the development of the OE field has become adversely affected compared to other health research fields. Finally, this thesis confirms that the rise and fall of a particular health research field is heavily influenced by specific past and contemporary social, economic and political factors. Engaging in social, economic and political matters, being open to new advances in research, and optimising networking opportunities with other disciplines, key researchers, policy-makers and other pertinent stakeholders and institutions may potentially facilitate progress in OE and other health research fields.

TABLE OF CONTENTS

1	INTRODUCTION.....	1
1.1	INTRODUCTION.....	1
1.2	BACKGROUND.....	2
1.3	DEFINITION OF KEY TERMS.....	8
1.3.1	<i>Public health</i>	9
1.3.2	<i>Occupational health</i>	11
1.3.3	<i>Epidemiology</i>	12
1.3.4	<i>Epidemiological Designs</i>	14
1.3.5	<i>Public health epidemiology</i>	16
1.3.6	<i>Specific features of occupational epidemiology</i>	17
1.3.7	<i>Cancer epidemiology</i>	18
1.3.8	<i>Molecular and Genetic epidemiology</i>	18
1.4	MOTIVATION FOR THE STUDY.....	19
1.5	THE STUDY AIMS AND OBJECTIVES.....	21
1.6	ORGANISATION OF THE THESIS.....	24
1.7	SUMMARY.....	26
2	BACKGROUND AND CONTEXT.....	27
2.1	INTRODUCTION.....	27
2.2	THE DEVELOPMENT OF OCCUPATIONAL HEALTH SERVICES IN THE UK.....	28
2.2.1	<i>Historical background</i>	28
2.2.2	<i>Compensation</i>	31
2.3	THE DEVELOPMENT OF OCCUPATIONAL HEALTH MEDICINE.....	32
2.3.1	<i>The Certifying Surgeons</i>	33
2.3.2	<i>Research in occupational health</i>	34
2.4	THE DEVELOPMENT OF THE HEALTH AND SAFETY REGULATIONS AT WORK.....	42
2.4.1	<i>The Robens Report</i>	42
2.4.2	<i>The Health and Safety at Work etc. Act 1974 (HSWA)</i>	44
2.4.3	<i>The Health and Safety Executive</i>	46
2.4.4	<i>Recent developments</i>	47
2.5	KEY FACTORS INFLUENCED THE DEVELOPMENT OF OCCUPATIONAL HEALTH IN THE UK.....	49
2.5.1	<i>The Exclusion of occupational health from the NHS</i>	49
2.5.2	<i>Education in occupational medicine</i>	55
2.5.3	<i>Changes in the UK higher education research funding system</i>	57

2.5.4	<i>Deindustrialisation</i>	59
2.6	THE DEVELOPMENT OF PUBLIC HEALTH FIELD	62
2.6.1	<i>The nineteenth century until 1948</i>	62
2.6.2	<i>During the establishment of the NHS</i>	63
2.6.3	<i>The 1974 reorganisation</i>	64
2.6.4	<i>During the Labour government since 1997</i>	66
2.6.5	<i>Current developments</i>	67
2.7	MEDICAL WORKFORCE IN OH COMPARED WITH THOSE IN PH FIELD	68
2.7.1	<i>Specialty training workforce in occupational medicine (OM)</i>	72
2.8	SUMMARY	74
3	THE REPORTED CHALLENGES AND FACILITATORS OF OE RESEARCH IN THE UK	76
3.1	INTRODUCTION.....	76
3.2	STAGE 1: THE SCOPING REVIEW	76
3.3	STAGE 2: MAIN REVIEW SEARCH STRATEGY	77
3.3.1	<i>Search terms</i>	77
3.3.2	<i>Criteria for Study Inclusion</i>	78
3.3.3	<i>Data extraction and analysis</i>	78
3.3.4	<i>The main review search results</i>	79
3.4	STAGE 3: THE REVIEW OF ORIGINAL OE PAPERS FROM THE HAND SEARCH OF KEY JOURNALS	79
3.4.1	<i>The Journals search methods</i>	79
3.4.2	<i>Data extraction and analysis</i>	80
3.4.3	<i>Journal search results</i>	80
3.5	RESULT FROM MAIN REVIEW AND JOURNALS CONTENTS PAGE REVIEWS	81
3.5.1	<i>Description of included studies</i>	81
3.5.2	<i>Study themes</i>	81
3.6	DISCUSSION OF BOTH REVIEWS.....	84
3.7	CONCLUSIONS	86
4	RESEARCH METHODOLOGY	88
4.1	INTRODUCTION.....	88
4.2	ONTOLOGICAL AND EPISTEMOLOGICAL CONSIDERATIONS	88
4.3	PARADIGM DEBATE	91
4.4	THE CASE FOR PRAGMATISM.....	91
4.5	RESEARCHER WORLDVIEW AND THE STUDY METHODOLOGY	93

4.6	OVERALL RESEARCH DESIGN- SEQUENTIAL, EXPLORATORY, MIXED-METHODS DESIGN	94
4.6.1	<i>What is mixed-methods approach?</i>	94
4.6.2	<i>How can the methods be implemented?</i>	96
4.6.3	<i>The level of priority given to either quantitative or qualitative methods</i>	97
4.6.4	<i>Purpose and stage of integration</i>	98
4.7	ETHICAL CONSIDERATIONS	100
4.7.1	<i>Informed consent</i>	100
4.7.2	<i>Privacy and confidentiality</i>	100
4.8	SUMMARY	101
5	CHALLENGES TO & FACILITATORS OF OCCUPATIONAL EPIDEMIOLOGY RESEARCH IN THE UK	102
5.1	INTRODUCTION	102
5.2	AIMS AND OBJECTIVES	102
5.3	PART 1: EXPLORATION OF THE PERCEPTIONS OF THE CHALLENGES AND THE FACILITATORS OF OCCUPATIONAL EPIDEMIOLOGY RESEARCH IN THE UK	103
5.3.1	<i>Introduction</i>	103
5.3.2	<i>Method</i>	104
5.3.3	<i>Validity in Qualitative approaches</i>	109
5.3.4	<i>Reflexivity</i>	110
5.4	QUALITATIVE STUDY RESULTS	111
5.4.1	<i>Participants</i>	111
5.4.2	<i>Qualitative phase results</i>	111
5.4.3	<i>Discussion of the qualitative phase results</i>	124
5.4.4	<i>Summary</i>	127
5.5	PART 2: SURVEY OF UK-BASED OE RESEARCHERS	127
5.5.1	<i>Introduction</i>	127
5.5.2	<i>Quantitative Phase methods</i>	127
5.5.3	<i>Quantitative Phase Analysis</i>	129
5.5.4	<i>Reliability in Quantitative approaches</i>	129
5.5.5	<i>Quantitative Phase Results</i>	130
5.5.6	<i>Discussion of the survey phase</i>	136
5.6	PART 3: DISCUSSION OF THE OVERALL STUDY FINDINGS	137
5.6.1	<i>Lack of human and financial resources</i>	137
5.6.2	<i>Declining interest in OE field</i>	137
5.6.3	<i>Lack of expertise and cutting edge methodologies and techniques</i>	140

5.7	CONCLUSION.....	141
6	TRENDS IN THE DEVELOPMENT OF OCCUPATIONAL EPIDEMIOLOGY RELATIVE TO PUBLIC HEALTH EPIDEMIOLOGY	143
6.1	INTRODUCTION.....	143
6.2	AIMS AND OBJECTIVES OF THE BIBLIOMETRIC STUDY	145
6.3	METHODS.....	146
6.3.1	<i>Bibliometric analysis</i>	<i>146</i>
6.3.2	<i>Bibliometric analyses tools.....</i>	<i>147</i>
6.3.3	<i>Search strategy and study selection.....</i>	<i>148</i>
6.3.4	<i>Methodology for identifying eligible studies</i>	<i>149</i>
6.3.5	<i>Search filter</i>	<i>153</i>
6.3.6	<i>Data extraction, management and organisation</i>	<i>154</i>
6.3.7	<i>Data analysis</i>	<i>155</i>
6.4	RESULTS	156
6.4.1	<i>Bibliographic database search results</i>	<i>156</i>
6.4.2	<i>Bibliometric analysis results.....</i>	<i>157</i>
6.5	DISCUSSION	176
6.5.1	<i>Citation trends and characteristics.....</i>	<i>176</i>
6.5.2	<i>Research collaboration.....</i>	<i>180</i>
6.5.3	<i>The impacts of the use of new methodologies and techniques.....</i>	<i>180</i>
6.5.4	<i>The impact of scientific and technological developments</i>	<i>182</i>
6.5.5	<i>Key researchers' characteristics and influence.....</i>	<i>184</i>
6.5.6	<i>The impact of funding</i>	<i>185</i>
6.6	CONCLUSIONS	186
6.7	FUTURE RESEARCH.....	187
7	THE IMPACT OF FUNDING POLICIES AND ALLOCATIONS ON THE RISE AND FALL OF HEALTH RESEARCH DISCIPLINES	188
7.1	INTRODUCTION.....	188
7.2	BACKGROUND.....	188
7.3	AIMS AND OBJECTIVES OF THE DOCUMENTARY ANALYSIS PHASE.....	189
7.4	METHOD SELECTION.....	190
7.4.1	<i>Advantages of the documentary analysis.....</i>	<i>190</i>
7.4.2	<i>Document analysis method limitations</i>	<i>192</i>
7.4.3	<i>Data analysis</i>	<i>197</i>
7.5	RESULTS	202
7.5.1	<i>Funding bodies characteristics.....</i>	<i>202</i>

7.5.2	<i>Issues influenced funding decisions</i>	211
7.6	SECTION THREE: DISCUSSION.....	241
7.6.1	<i>Key leaders and researchers influence on funding policies and scientific fields' development</i>	241
7.6.2	<i>The influence of collaboration and technological, scientific and methodological development</i>	243
7.6.3	<i>The influence of internal and external policies</i>	246
7.6.4	<i>Conclusions</i>	248
8	DISCUSSION AND CONCLUSION	249
8.1	SUMMARY OF KEY FINDINGS	249
8.1.1	<i>Practical issues</i>	251
8.1.2	<i>Lack of human and financial resources</i>	252
8.2	SYNTHESIS AND DISCUSSION OF KEY FINDINGS	254
8.2.1	<i>Deindustrialisation</i>	255
8.2.2	<i>The exclusion from the NHS</i>	257
8.2.3	<i>Funding policies</i>	258
8.3	IMPLICATIONS AND RECOMMENDATION.....	264
8.3.1	<i>Reviewing the field and setting up research priorities</i>	264
8.3.2	<i>Education and training</i>	266
8.3.3	<i>Contributing to policy</i>	268
8.3.4	<i>Further Recommendations</i>	269
8.4	AREAS OF FUTURE RESEARCH.....	273
8.4.1	<i>Further explorations of issues influencing the development of health disciplines</i>	273
8.4.2	<i>Further bibliometric analysis</i>	274
8.4.3	<i>Barriers to OH speciality training</i>	274
8.5	STRENGTHS AND LIMITATIONS	275
8.5.1	<i>Study Strengths</i>	275
8.5.2	<i>Study Limitations</i>	276
8.6	THE GENERALISABILITY AND TRANSFERABILITY OF THE FINDINGS	278
8.7	CONCLUSIONS	279
9	REFERENCES	280
10	APPENDICES	301
	APPENDIX A-1: QUALITATIVE STUDY PARTICIPANTS INFORMATION SHEET	301
	APPENDIX A-2: CONSENT TO PARTICIPATION IN QUALITATIVE STUDY	304
	APPENDIX A-3: THE STUDY QUESTIONNAIRE COVER LETTER.....	306

APPENDIX B-1: THEMATIC ANALYSIS PROCESS OF THE REVIEW DATA	307
APPENDIX B-2: LIST OF JOURNALS INCLUDED IN THE REVIEW	308
APPENDIX B-3: PHASE TWO SEARCH ELIGIBLE ARTICLES CHARACTERISTICS	309
APPENDIX B-4: THE QUALITATIVE STUDY INTERVIEW SCHEDULE	314
APPENDIX B-5: THE STUDY QUESTIONNAIRE.....	315
APPENDIX B-6: RESEARCH CHALLENGES RESULTS	319
APPENDIX B-7: RESEARCH FACILITATORS RESULTS	321
APPENDIX C-1: BIBLIOMETRIC STUDY SEARCH STRATEGY.....	322
APPENDIX D-1: MRC, HSC, AND CRC ANNUAL REPORTS REVIEWED IN THE DOCUMENTARY STUDY.....	325
APPENDIX D-2: ANALYTICAL FRAMEWORK FOR THE DOCUMENTARY ANALYSIS.....	327
APPENDIX D-3: MRC FUNDED FIELDS	329
APPENDIX D-4: PROJECTS LIST OF EPIDEMIOLOGICAL STUDIES FUNDED BY CRC 1980-1990	331
APPENDIX D-5: CASE STUDIES TO ILLUSTRATE THE INFLUENCE OF KEY LEADERS AND RESEARCHERS	338

LIST OF TABLES

TABLE 1-1: AIMS AND OBJECTIVES OF EACH PHASE OF THE THESIS.....	23
TABLE 2-1: OCCUPATIONAL HEALTH RESEARCH WITHIN THE MRC DURING 1947/48 AND 1970/71.....	37
TABLE 2-2: HOURS GIVEN TO FORMAL TEACHING IN OCCUPATIONAL MEDICINE TO MEDICAL UNDERGRADUATES IN THE UK FROM 1970 TO 2010	55
TABLE 2-3: THE TOTAL NUMBER OF OCCUPATIONAL HEALTH PHYSICIANS COMPARED TO PUBLIC HEALTH PHYSICIANS AND THE TITLE OF THESE AT VARIOUS TIME POINTS.	70
TABLE 2-4: TOTAL NUMBER OF THE FOM MEMBERSHIP FROM 1995 TO 2014, THE FPH FROM 1996 TO 2003, AND THE NUMBER OF OCCUPATIONAL AND PH PHYSICIANS WORKING IN THE NHS.....	71
TABLE 2-5: NUMBER OF OH SPECIALTY REGISTRARS (SPRS) IN POSTS.....	72
TABLE 2-6: NUMBER OF OM TRAINEE IN THE UK.....	73
TABLE 3-1: SEARCH TERMS OPERATION STRATEGY	77
TABLE 4-1: STUDY DESIGN AND METHODS OF ANALYSIS	97
TABLE 5-1: LENGTH OF PARTICIPANTS' EXPERIENCE.....	130
TABLE 5-2: PARTICIPANTS' ROLES.....	131
TABLE 5-3: LIST OF ADDITIONAL CHALLENGES TO OE RESEARCH AND NUMBER OF RESPONSES	132
TABLE 5-4: CHALLENGES CONSIDERED BEING THE MOST IMPORTANT	133
TABLE 5-5: STRATEGIES EMPLOYED TO OVERCOME RESEARCH CHALLENGES	134
TABLE 5-6: FACILITATORS CONSIDERED BEING THE MOST IMPORTANT.....	135
TABLE 5-7: RESEARCHERS ANSWERS TO WHETHER THEIR STUDIES WERE PREMATURELY STOPPED, COMPROMISED, OR DELAYED.....	135
TABLE 5-8: REASONS FOR STUDIES' DELAYS	136
TABLE 6-1: ELIGIBLE ARTICLES FOUND IN FIVE JOURNALS AND WHETHER THEY WERE RETRIEVED BY THE DATABASE SEARCH STRATEGY	150
TABLE 6-2: TOP 20 MOST CITED PHE ARTICLES PUBLISHED DURING THE PERIOD 1978 – 2004.	161
TABLE 6-3: TOP 20 MOST CITED OE ARTICLES PUBLISHED DURING THE PERIOD 1965 – 2005.	162
TABLE 6-4: AVERAGE NUMBER OF AUTHORS PER ARTICLE OVER TIME	165
TABLE 6-5: NUMBER AND PERCENTAGE OF STUDIES WRITTEN BY ONE TO MORE THAN 10 AUTHORS	166

TABLE 6-6: TOP 20 HIGHLY CITED PHE AUTHORS AND WHETHER THEY ARE STILL ACTIVE IN THE FIELD	169
TABLE 6-7: TOP 20 PRODUCTIVE PHE AUTHORS AND WHETHER THEY ARE STILL ACTIVE IN THE FIELD.....	170
TABLE 6-8: TOP 20 HIGHLY CITED OE AUTHORS AND WHETHER THEY ARE STILL ACTIVE IN THE FIELD.....	171
TABLE 6-9: TOP 20 PRODUCTIVE OE AUTHORS AND WHETHER THEY ARE STILL ACTIVE IN THE FIELD.....	172
TABLE 6-10: TOP 10 OE JOURNALS BASED ON PUBLICATION SIZE AND IMPACT FACTOR	173
TABLE 6-11: TOP 10 PHE JOURNALS BASED ON PUBLICATION SIZE AND IMPACT FACTOR.....	174
TABLE 6-12: TOP 10 INSTITUTIONS THAT HAVE PUBLISHED LEADING OE PAPERS.....	175
TABLE 6-13: TOP 10 INSTITUTIONS THAT HAVE PUBLISHED LEADING PHE PAPERS	175
TABLE 7-1 : NUMBER AND TYPES OF EPIDEMIOLOGICAL STUDIES FUNDED BY CRC 1980-1990	238
TABLE 8-1: KEY FINDINGS FROM ALL PHASES	250

LIST OF FIGURES

FIGURE 1-1: AN OVERVIEW OF THE PHASES OF THIS PHD RESEARCH PROGRAMME	22
FIGURE 5-1: A SCREENSHOT OF CODED TEXT IN MAXQDA SOFTWARE PACKAGE.	108
FIGURE 6-1: A SCREENSHOT OF DATA ANALYSIS USING HISTCITE.	155
FIGURE 6-2: A FLOW-CHART ILLUSTRATING THE PROCEDURE EMPLOYED IN THE REFINEMENT OF BIBLIOMETRIC SEARCH RESULTS.	156
FIGURE 6-3: TEMPORAL TRENDS IN OE PUBLICATIONS VERSUS PHE PUBLICATIONS IN THE PERIOD FROM 1965 TO 2012.	157
FIGURE 6-4: TEMPORAL CITATION TRENDS OF OE AND PHE STUDIES DURING THE PERIOD 1965-2012.	158
FIGURE 6-5: (A) OE & PHE PUBLICATIONS AND CITATION TRENDS VERSUS PUBLICATION YEAR (B) NUMBER OF PHE PUBLICATION VS NUMBER OF CITATIONS PER YEAR (C) NUMBER OF OE PUBLICATION VS NUMBER OF CITATIONS PER YEAR. THE SOLID LINES IN (B) AND (C) REPRESENT LINEAR REGRESSION FITTED TO DATA.	159
FIGURE 6-6: THE IMPACT OF THE APPLICATION OF GENETIC- AND MOLECULAR-BASED TECHNIQUES ON THE NUMBER OF PUBLICATIONS AND GROWTH OF THE PHE FIELD.	160
FIGURE 6-7: TEMPORAL TREND OF NEW UK-BASED OE AND PHE AUTHORS ENTERING THE FIELD DURING THE PERIOD 1965 –2012.....	165
FIGURE 6-8: PERCENTAGE OF OE AND PHE STUDIES AUTHORED BY ONE TO MORE THAN 10 AUTHORS	166
FIGURE 6-9: TREND OF PHE CO-AUTHORSHIP DURING THE PERIOD 1965 - 2012.....	167
FIGURE 6-10: TREND OF OE CO-AUTHORSHIP DURING THE PERIOD 1965 - 2012.....	168
FIGURE 7-1: TEMPORAL TREND OF THE MRC INCOME (PARLIAMENTARY GRANT-IN-AID AND OTHER TOTAL INCOME).	204
FIGURE 7-2: MRC RESEARCH EXPENDITURE FROM 1980 – 1995.	206
FIGURE 7-3: MRC FUNDING TREND OF DIFFERENT RESEARCH AREAS.	207
FIGURE 7-4: CRC INCOME DURING 1980-1995.	209
FIGURE 7-5: CRC EXPENDITURE ON CANCER RESEARCH COMPARED WITH MRC.	209
FIGURE 7-6: HSC EXPENDITURE ON RESEARCH, TESTING AND AGENCY SERVICE.	211

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LIST OF ABBREVIATIONS AND ACRONYMS

ABRC	The Royal Society and the Advisory Board for the Research Councils
ACARD	The Advisory Council for Applied Research and Development
ADP	AIDS Directed Programme
AMED	The Allied and Complementary Medicine Database
AMS	Academy of Medical Science
APMS	Adult Psychiatric Morbidity Survey
AR	Annual report
BA	Bibliometric Analysis
BMA	British Medical Association
BMJ	British Medical Journal
CAQDAS	Computer Assisted Qualitative Data Analysis
CERG	The CRC Cancer Epidemiology Research Group
CfWI	The Centre for Workforce Intelligence
CHAP	The Corporate Health and Performance Group
CIM	Cumulated Index Medicus
CINAHL	Cumulative Index of Nursing and Allied Health Literature
CJS	Quantitative methods expert Dr Chris J Sutton
CLML	Current List of Medical Literature
CNS	Central Nervous System
COREC	Central Office for Research Ethics Committees
COSHH	Control of Substances Hazardous to Health
CRC	Cancer Research Campaign
CTD	EU Clinical Trials Directive
DMM	Field expert supervisor Prof Damien McElvenny
DNA	Deoxyribonucleic acid
DoH	Department of Health
DPA	The Data Protection Act
DWP	Department for Work and Pensions
EBM	Evidence Based Medicine

Embase	Excerpta Medica dataBASE: a biomedical and pharmacological database
ENCR	The European Network of Cancer Registries
EPICOH	International Conference on Epidemiology in Occupational Health
FA	Framework Analysis
FOM	Faculty of Occupational Medicine
FPH	Faculty of Public Health
GP	General Practitioner
HEIs	Higher Education Institutions
HGMP	Human Genome Mapping Programme
HIV	The Human Immunodeficiency Virus
HRA	The Health Research Agency
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSL	The Health and Safety laboratory
HSWA	The Health and Safety at Work etc. Act 1974
IARC	The International Agency for Research on Cancer
ICRF	The Imperial Cancer Research Fund
ILO	The International Labour organization
IOM	Institute of Occupational Medicine
IRAS	Integrated Research Application System
IRBs	Institutional Review Boards
LFS	Labour Force Survey
LMB	Laboratory for Molecular Biology
LREC	Local Research Ethics Committee
MeSH	Medical Subject Headings
MOH	Medical Officer of Health
MOsH	The medical officers of health
MP	Member of Parliament
MRC	The Medical Research Council
MREC	Multicentre Research Ethics Committee

NCB	National Coal Board
NHS	National Health Service
NHSCR	National Health Service Central Register
NIBSC	The National Institute for Biological Standards and Control
NIGB	National Information Governance Board for Health and Social Care
NIHR	National Institute for Health Research
NIHR CRN	The National Institute for Health Research Clinical Research Network Coordinating Centre (formally known as UKCRN)
NIHR CSP	National Institute for Health Research Coordinated System for gaining NHS Permission
NIMR	The National Institute of Medical Research
NLM	National Library of Medicine
NORA	National Occupational Research Agenda
NRES	National Research Ethics Service
OE	Occupational Epidemiology
OEM	Occupational Medicine and Occupational and Environmental Medicine
OH	Occupational Health
OM	Occupational Medicine
ONS	The Office for National Statistics
PCTs	Primary Care Trusts
PFR	The British National Coal Board's Pneumoconiosis Field Research
PHE	Public Health Epidemiology
PIAG	Patient Information Advisory Group
PRU	Pneumoconiosis Research Unit
R&D	Research & Development
RAE	The Research Assessment Exercise
RCTs	Randomised Controlled Trials
REC	Research Ethics Committee
RECs	Research Ethics Committees
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulation
SD	Mixed-method expert supervisor Prof Soo Downe

SERC	The Science and Engineering Research Council
SMEs	Small and medium-sized enterprises
SPSS	Statistical Package for Social Sciences
SR	Systematic Review
THOR	The Health and Occupation Research network
TUC	The Trades Union Congress
UCLan	University of Central Lancashire
UFC	The Universities Funding Council
UKCRC	The UK Clinical Research Collaboration
WHO	World Health Organisation
WoS	The ISI-Thomson Web of Science
WT	The Wellcome Trust

STATISTICAL SYMBOLS

n: Sample size

μ : Percentage of a population (e.g., number of studies)

r: Pearson correlation coefficient; a measures the linear association between two continuous variables.

p-value: a measure of statistical significance and refers to the likelihood that an observed result could have arisen by chance alone provided the null hypothesis is true.

1 INTRODUCTION

1.1 Introduction

There has been anecdotal evidence indicating that occupational health (OH) and research within this field are facing many challenges and research workforce, funding, and outputs in this area are declining (Black, 2008b; Engel, 1990; Faculty of Occupational Medicine, 2006, 2011; Harrington & Seaton, 1988; Nicholson, 2004; Schilling, 1993; Vanhoorne et al., 1985; Vaughan-Jones & Barham, 2009; Wynn, Williams, Snashall, & Aw, 2003). Nevertheless, no empirical studies have been undertaken to explore these issues. This is despite research in this field particularly epidemiological studies having significantly contributed to identification of work-related health issues, and the fact that many work-related diseases and injuries have continued to occur due to exposure to new and less recognisable risks at work as well as lower level of exposures to hazardous substances (Checkoway, Pearce, & Kriebel, 2004b).

This thesis hence presents an examination of the past and current challenges faced by practitioners of occupational epidemiology (OE) in the UK, as well as the facilitators. It also highlights what researchers in OE and other health research disciplines, such as public health epidemiology and clinical research, can learn from the findings of this investigation (detailed aims and objectives are in section 1.5). This research addresses these issues using a mixed-methods approach and, in the last two phases of the study, compares findings in OE with those in another similar field, specifically public health epidemiology (PHE).

The original contribution of knowledge of thesis is twofold. First, it provided comprehensive empirical findings of the challenges to and facilitators of the field of OE, which originated from key inextricably interwoven social, economic and political issues such as deindustrialisation, the exclusion of OH from the National Health Service (NHS), and the neoliberal government policies in relation to the focus on efficiency and economic

return of health research, and the higher education research auditing process. This analytical framework could be adjusted as relevant and utilised to explore the rise and fall of other health research fields. Second, a novel approach of undertaking a bibliometric analysis was developed. To the author's knowledge, this approach has never been tried before. The novelty of this approach lies in the completeness and volume of publication data it draws on, and the level of detail included about the characteristics of publications, researchers and their institutions. Additionally, the way in which this approach was undertaken within a health research field is also systematic and unique, which can be employed to systematically study the characteristics of other health research fields. In that respect, a combination of different databases was used for different purposes; to systematically identify relevant publications for analysis (by using Medline), to collect comprehensive bibliometric data about the identified publications (by using Web of Science), and to efficiently extract relevant bibliometric data for analyses (by using Histcite).

It is also worth noting that there are different approaches that this investigation could have taken, in particular a sociological interpretative approach, which could have taken the investigation in a different direction. However, in this thesis a pragmatic approach was followed in all aspects of the investigation including the choice of methodology as discussed in chapter three. This direction is essential, particularly given that the target audience (e.g. OH practitioners and researchers, policymakers, and potentially other stakeholders from various institutions and health fields) who could benefit from this investigation are facing practical challenges and may benefit or comprehend those findings that are more pragmatic in nature. Still, sociological issues were touched upon when that fitted with this approach.

In the following sections of this chapter a brief background of the thesis is presented, which will be discussed in more in-depth in the second chapter of this thesis. Then, discussion of the definitions of key terms, which are used throughout this thesis but most importantly are required for the bibliometric study in chapter six, is provided. The motivation for the programme of studies is then discussed followed by an overview of the aims and objectives, a discussion of the organisation of the thesis, and finally a brief summary of the chapter.

1.2 Background

Occupation is a major contributor to ill-health among adults (Elms et al., 2005). Nonetheless, approximately 70% of the national workforce and almost all of the unemployed have no access to specialised occupational health care in the UK (FOM, 2010).

The risk of disease or injury in the workplace should be minimised, yet many thousands of workers in the UK are long-term sufferers of occupational diseases and injuries (Mounstephen, 2015).

According to the Health and Safety Executive (HSE), about 1.2 million (3.9%) of the 30.61 million people who worked during 2013-2014 in the UK were suffering from an illness they believed was caused, or made worse by their current or past work. Critically, over 555,000 of these were new cases of work related illness, and about 80% of these were either musculoskeletal disorders or stress, depression or anxiety (HSE, 2014). The HSE also reported the death of 133 workers from accidents and a loss of a total of 28.2 million work days (HSE, 2014). Furthermore, it has been estimated that 5.3% of all cancer deaths, and around 4% of all cancer registrations per year in Great Britain, could be attributed to past occupational exposures to known carcinogens (Rushton et al., 2010). Workplace injury and work-related ill-health also impose social and economic costs on individuals, families, the community, employers and the Government (Burton et al., 2002). In the UK, in the calendar year of 2012-2013 alone, the HSE estimated a total loss of £14.2 billion due to workplace injury and ill-health (excluding occupational cancers) (HSE, 2014).

The main intertwined developments that are most likely to affect the health of the workforce in the UK in the period up to 2030 are the changing demography and economy, developments in work and employment, and the evolution of diseases (Vaughan-Jones, 2009). The growing burden of all ill-health coupled with the changing demographics of the UK workforce are causing great challenges for the country, especially for maintaining its long term productivity and competitiveness. By 2024, it is estimated that nearly half of the UK adult population will be aged 50 or over (Taylor, 2007). There will be a great demand for people to work well past their present retirement age (Webb, 2012). This means that ensuring optimum health of the working population is crucial to achieve this aim (Vodopivec & Dolenc, 2008). When the health of the workers is improved, there is a better chance of extending their working lives (Vodopivec & Dolenc, 2008).

In 2008, Dame Carol Black reviewed the health of Britain's working age population and estimated that improved workplace health could generate cost savings to the government of over £60 billion a year; the value of nearly two thirds of the NHS budget for England (Black, 2008b). Nonetheless, the economic recession, which coincided with this review, has adversely affected occupational health services. The pan-European opinion poll on occupational safety and health (OSH) found that 61 per cent of the workers participating in

the poll believed that economic recession would “a great deal” or “to some extent” affect OH services, and only 34 per cent answered “not really” or “not at all”(European Agency for Health and Safety at Work, 2009).. Another study by the International Labour Office (ILO) (2013, p. 31) concluded that a number of potential threats exist for OSH due to the economic recession, including:

- *“a focus on productivity and growth leading to a distraction on OSH;*
- *an increase in psychosocial risks due to organizational restructuring;*
- *further increases in workload with insufficient resources.”*

Therefore, continuous assessment and improvements of occupational health and safety is crucial in preventing illnesses and injuries, as well as in reducing the high economic and social costs of work-related health issues, both for those affected and for society as a whole. Nevertheless, the UK medical workforce in OH field is small compared to other developed countries. For instance, there are 5 occupational physicians for every 100,000 workers in the UK compared to 61 in Finland (Nicholson, 2004). Additionally, only 15% of all UK employers provide OH support (this includes hazard identification, risk management, and provision of information) for their employees (Pilkington, Graham, & Cowie, 2002). Still when a more stringent definition of OH support is used (hazard identification, risk management, provision of information, modifying work activities, providing training on occupational health-related issues, measuring workplace hazards, and monitoring trends in health), only 3% of UK employers provide OH support. Compliance with the health and safety regulations imposed by the HSE is one of the motives for establishing such OH provisions. However, making access to occupational health a legal obligation is also insufficient for improving the workers’ health (Nicholson, 2002; Valk, Oostrom, & Schrijvers, 2006), which can only be accomplished by a comprehensive strategy for health improvement (Nicholson, 2004).

Furthermore, there are many workers who are still exposed to potential workplace health hazards and possible risks, and new risks continue to be discovered, thus it is important that further research is carried out to confirm whether or not they pose health risks, so that risks can be eliminated or minimised (Siemiatycki et al., 2004). It is also essential to further increase our understanding of the relative importance of work-related causes of diseases, to identify health and safety strategies, to improve the wellbeing of the working population, and to evaluate their economic and social impacts. This is where occupational epidemiology (OE) can play a key role and hence, facilitating the conduct of this type of research is important for the society as a whole and for the national economy.

OE is the study of the effects of workplace exposures including psychosocial, chemical, biological, or physical agents (e.g., stressful jobs, environmental toxins, zoonoses, radiation), on the frequency and distribution of diseases, and injuries in the working population (Checkoway, Pearce, & Kriebel, 2004a). It can contribute to identifying, evaluating and quantifying the possible causes of diseases and the hazardous exposures (Checkoway et al., 2004a). Increasing attention is now being given to studying the effects of workplace psychosocial and ergonomic exposures and the evaluation of specific measures to reduce exposure.

The OE field has contributed enormously to the identifications of workplace risks and several workplace improvements had been introduced as a result, which has played a vital role in improving the health of the working population. For example; up to 1970s, most known human carcinogens such as asbestos and vinyl chloride monomer, were discovered through OE studies (Coggon, 1999), and they still represent a large fraction of the recognised non-occupational carcinogens (Siemiatycki et al., 2004).

Furthermore, due to deindustrialisation, improvements in working environment, and technological development, the profile of risks has changed considerably in many occupations (Rushton, Hutchings, & Driscoll, 2013). For example, metalworking fluids (e.g., machine lubricating oils) that could have increased the risk of cancer among workers have been replaced by other formulations over the years. This change also brought new working conditions and agents of potential health risks. The identification of possible associations between new potential occupational risks and diseases is, therefore, increasingly required. It could also be argued that most of the high-risk effects have been identified and currently the focus should be on trying to identify lower risk hazards.

Despite that there are many thousands of chemicals in workplaces, and new ones are continuously being introduced; nevertheless, only a small fraction of occupational agents have been adequately investigated with epidemiologic data (Siemiatycki et al., 2004). For example, Ward et al. (2010) identified research gaps for 20 carcinogens and argued that there is a decline in research interest in occupational carcinogens. The main reasons for this decline according to Siemiatycki et al. (2004, p. 1456) include, *“the magnitude of the numbers of agents to be investigated, a shift away from occupational cancer research in the epidemiologic community and into new areas of epidemiologic interest, the difficulty and challenge of exposure assessment, and increasing barriers to accessing human subjects for occupational studies”*. He goes on to argue that *‘These are problems that deserve attention,*

or we will fail in our responsibilities'. In addition, occupational hazards could be perceived less of a problem, particularly due to the long latency of some of the occupational diseases (e.g., lung cancer, asbestos, and mesothelioma) (Rogers, Evans, & Wright, 2009). Besides the above issues, several new important areas for further OH research have been identified for particular occupational groups such as women, young workers, and migrant workers (Bevan, 2010).

OE is also a crucial element of the practice of occupational medicine (OM) in several ways; it contributes to (Guidotti, 2000):

- evidence-based medical dispute resolution (such as judgment in workers' compensation, third-party litigation and insurance settlements),
- informing the setting of occupational exposure limits,
- priority-setting in occupational health and safety practice,
- designing regular health-surveillance protocols,
- supporting workers' education,
- identifying potential aetiological mechanisms,
- supporting interventions in relation to prevention,
- identifying occupational hazards.

Therefore, the practice of OM can be suboptimally informed if OE does not produce sufficient evidence for possible new occupational hazards and exposures; does not progress in better characterisation of exposure-response relationships; or if it relies on outdated databases and surveillances (Checkoway et al., 2004a). This is particularly crucial for the evidence-based resolutions of disputes, which serves the interest of both workers and employers. For example, disability or mortality related compensation claims to previously unidentified occupational risks may be unfairly rejected due to the lack of evidence. Additionally, decisions on individual cases that depend on an interpretation of the literature (available evidence) will become increasingly difficult to be made, because of insufficient data to make a strong causal relationship (Guidotti, 2000).

There is also a need for more robust data in relation to specific categories of workers and specific work-related health issues (Bevan, 2010). The data for OE research, to some extent, comes from OH services. OH services are provided for a defined population; therefore, denominators for rates are fairly easy to define (Karvonen & Mikheev, 1986). The services usually record information on the state of health of the workers and hence are able to capture new cases of ill-health (Karvonen & Mikheev, 1986). Supportive information on

sickness absenteeism, pensions, and mortality may also be held. However, not all industries keep OH records of their employees, and the information collected may vary from one industry to another (Betts & Rushton, 1998; Rushton & Betts, 2001).

The HSE also provide several other sources, but each alone is not sufficient to give the required information (HSE, 2015). There are also other national sources such as Office of National Statistics (ONS) data (e.g. on cancer registration), and death certificates. However, in most studies, none of these sources alone would be sufficient to provide information for epidemiological studies, and a combination of all or some of these would be necessary (Health and Safety Executive, 2003). This could potentially pose difficulties in conducting OE studies because of the various clearances required to access data and participants or both. Additionally, as discussed above, OH services in the UK are limited and the medical workforce is small. In this regard, occupational physicians are potentially the key professionals who may possibly detect a work-related health issue and may also be the first to suggest or initiate an epidemiological investigation. All of these issues could also make it even more challenging to conduct OE research in the UK.

Despite the increasing importance in undertaking epidemiological research (Robertson, 2015; Ward et al., 2010), this field is currently facing challenges. Ward et al. (2010) recommended formal examinations of the challenges in this field by measuring its productivity and exploring issues related to ethical, legal, and funding difficulties. Additionally they cautioned that, if measures are not taken to address the challenges and identify and take up the opportunities in this area of research, further decline in epidemiologic knowledge base for the evaluation of potential carcinogens will continue (Ward et al., 2010). Baxter (1991) argued that funding of occupational health research in the UK is extremely low. He found that there is not any source of funding from the Department of Health (DoH) or the HSE dedicated for OH research within the NHS. Funding from pharmaceutical industry is also not available because, according to Baxter (1991), OH research is not routinely involved in treatment (i.e. employs mainly observational approaches). More seriously, the OH services and the workforce within this field is seriously diminishing (Black, 2008b; Faculty of Occupational Medicine, 2011), which may negatively affect the volume and quality of epidemiological research conducted in this field (Workforce issues are discussed in chapter two). The isolation of occupational health from the NHS, (further discussion is in chapter 2), has also had a major negative influence on its development and hence on research in this field.

In conclusion, OH is clearly an important element of public health; it can reduce work-related illnesses and injuries; thus reducing both economic and social costs for individuals, the society, industries, and the government. OE is the primary research area in both OH and OM. This field produces evidenced-based information in relation to the workplace risks and recommends improvements and preventative measures (Checkoway et al., 2004; Guidotti, 2000; Newill, 1983; Vanhoorne et al., 1985). Such improvements and preventative measures, if implemented, can contribute significantly to the working population's health, and more widely to the public health. However, there is anecdotal evidence, as discussed above, suggesting that OE (and OH in general) is facing many challenges including a diminishing workforce and reduced funding and interest in this field, which adversely affecting the workers' health. This is evident in the current high cost of work-related health issues imposed on workers, the community, industries, and the government (Black, 2008).

It is hence important to explore these challenges empirically; to understand why despite the benefits of this field, it is facing these issues, and what the facilitators are. Understanding the general challenges to and facilitators of OE research will help the field, and potentially other similar fields, to be better prepared to face the challenges and identify and take up the opportunities in order to conduct research that will improve the health of the working population, and ultimately the health of the public. It may also provide a framework that can be used to assess the status of other similar health research fields. This study sought to explore these challenges and the efforts and strategies needed to address them.

A more detailed discussion of the issues above along with the background and context of this research is presented in chapter two. In the next section, the definitions of key terms utilised throughout this thesis are presented.

1.3 Definition of key terms

This section provides a brief elucidation of the key terminology and concepts used throughout this thesis. Providing definitions for these terms is important particularly for the bibliometric study, where workable definitions are required so that OE and public health epidemiology studies are identified and distinguished from each other to allow comparison. Hence, a pragmatic approach is followed in providing these definitions. The key terms are:

- Public health
- Occupational health
- Epidemiology
- Epidemiological designs

- Public health epidemiology
- Specific features of occupational epidemiology
- Cancer epidemiology
- Molecular and Genetic epidemiology

1.3.1 Public health

The current accepted definition of public health within the UK health policy is that of Acheson (1998, p. 1), which is:

‘the science and art of preventing disease, prolonging life and promoting health through the organised efforts of society.’

According to Acheson (1998, p. 1):

‘these efforts will address policy issues at the level of the population’s health and will tackle the role of health and disease, as well as considering the provision of effective health care services. Public health works through partnerships that cut across disciplinary, professional and organisational boundaries, and exploits this diversity in collaboration, to bring evidence and research based policies to all areas which impact on the health and well-being of populations.’

Childress et al. (2002, p. 170) noted that:

‘Public health is primarily concerned with the health of the entire population, rather than the health of individuals. Its features include an emphasis on the promotion of health and the prevention of disease and disability; the collection and use of epidemiological data, population surveillance, and other forms of empirical quantitative assessment; a recognition of the multidimensional nature of the determinants of health; and a focus on the complex interactions of many factors – biological, behavioural, social, and environmental- in developing effective interventions.’

Childress et al. (2002) definition includes not only an account of the aims of public health (a focus on the entire population) and the determinants of health, but it also includes a list of certain public health methodologies.

As indicated from these definitions, public health activities can be complex, and also include: community collaborations and partnerships for health, identification of priorities for public health action, multidisciplinary, and the use of different methodologies from those of traditional medicine (Childress et al., 2002).

The scientific basis of public health activities primarily derives from:

- the basic sciences such as pathology and toxicology,
- the clinical or medical sciences such as medicine and paediatrics, and
- the public health sciences such as epidemiology, environmental health science, and health education and behavioural science.

Research in the above three areas approach research questions from different, yet complementary, perspectives and provide the scientific foundation for public health action. Therefore, public health providers have a small core of common training, due to the many fields of knowledge that become relevant when one deals with factors outside the individual. There are many activities and organisations that blend both clinical and public health approaches (Schoenbach & Rosamund, 2000). For example, epidemiologic methods are currently being applied to clinical medicine in the field of clinical epidemiology and newly developed areas of epidemiologic research are now inclusive of basic sciences such as molecular and genetic epidemiology (Carr, Unwin, & Pless-Mulloli, 2007).

The scope of public health is much broader than that of the clinical approach. Public health focuses mainly on disease prevention rather than disease treatment and diagnosis, though prevention in this context generally means preventing the occurrence of disease in individuals (Schoenbach & Rosamund, 2000). The units of concern in public health are groups of people living in the community rather than separate individuals visiting a healthcare facility (Parfrey & Barrett, 2009). However, any given population may be considered as comprising of various communities; hence, public health usually focuses on a population or subgroups within it (Schoenbach & Rosamund, 2000). For instance, in occupational epidemiology the target population is the working population, which is a subgroup of the general population. Working population also consists of other various subgroups depending on the purpose and type of the study; such as workers and employees in particular industries and organisations.

Public health is also concerned with the organisation of society and the protection of the environment, and focuses on the future (Carr et al., 2007). Thus, public health often refers, not merely to the state of health of the public, but also to a practice or a set of interventions aiming to protect the health of the public, which is clear in Acheson's (1998, p. 1) definition, '*... through organised community efforts*'. Approaches for intervention are broad, as they can deal with individuals, families, government organizations, the media and the

physical environment. These interventions are somehow organised either by public institutions or they are carried out through aggregated efforts of different professionals and organisations. Thus, it would be impossible to carry out these interventions without cooperation between (groups of) individuals.

1.3.2 Occupational health

Occupational health is '*the promotion and maintenance of the highest levels of physical, mental, and social wellbeing of workers in all occupations by preventing departures from health, controlling risks, and adapting of work to people and people to their jobs*' (Tulchinsky & Varavikova, 2009, p. 358).

Occupational health is one of the oldest sectors of public health that deals with safety and health issues in the work environment. The pioneering work of the Italian physician Bernardino Ramazzini and his book *De Morbis Artificum Diatriba* (Diseases of Workers) which was printed in 1700, is the first known systematic documentation of occupational diseases (Checkoway, Pearce, & Kriebel, 2004). Classic eighteenth and nineteenth century examples of occupation related health hazards and diseases include: scurvy among sailors, cancer of the scrotum specific to chimney sweeps in eighteenth-century England, black lung in coal miners, mercury poisoning in hat makers, and byssinosis in cotton mill workers (Buck, Llopis, Najera, & Terris, 1989). More recent examples extend to mesothelioma in asbestos workers, musculoskeletal injuries and hepatitis-B in hospital workers, spinal disorders in typists, medial neuritis in computer workers (e.g., carpal tunnel syndrome) and work-related stress (Checkoway et al., 2004). Interventions can vary greatly, and can include preventative measures such as the ban of asbestos usage and the modification of the office work environment.

Diseases relating to occupation have always been an essential concern of public health (Tulchinsky & Varavikova, 2009). Furthermore, the worker may also be member of a family and possibly, the main source of income. Consequently, this makes his or her health an important factor for the overall health of the family. As the possible main source of income in his family, the worker cannot only be concerned with what happens at his place of employment but also with hazardous agents he or she might accidentally bring home (Tulchinsky & Varavikova, 2009). Furthermore, factories such as cement factories and metal smelters can cause air and water pollutions, which can affect the general public (Kjellstrom et al., 2006). Thus, occupational health in this wider context has an important place in public health.

1.3.3 Epidemiology

As noted by Detels et al. (2009), defining epidemiology is difficult especially when considered as a branch of medicine. This is because it does not represent a body of knowledge (e.g., anatomy) or target a specific organ system such as cardiology or neurology (Detels, 2009). Although a number of definitions for epidemiology have been proposed e.g., (Khoury et al., 2010; MacMahon & Pugh, 1970), Last's definition (2000, p. 62) captures the fundamental principles and the public health essence of epidemiology:

'The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.'

Last (2000, p. 62) highlighted that epidemiologists are not only concerned with disease but also with 'health-related events' (for example, disability, hospital admissions, and mortality), and that epidemiology is also dedicated to controlling diseases. However, it could be argued that the phrase '*...the application of this study to the control of health problems*' actually refers to a public health function rather than one that is related to epidemiology. Savitz, Pooie, & Miller (1999) argue that epidemiology contributes to the rationale for public health policies and services and is important for use in their evaluation, but the delivery of those services or the implementation of those policies is not part of epidemiology work. Additionally, not all epidemiological studies lead to benefits in public health (Pearce, 1999).

The terms used in the broad definition of epidemiology can be further elaborated as follows (Carr et al., 2007):

'Study' refers to using quantitative, scientific research approaches including; surveillance, observation, analytic research and experiments.

- Observational studies: these involve no intervention other than asking questions, carrying out medical examinations, accessing health records or registers and simple laboratory tests or X-ray examinations.
- Experimental studies: the investigator intentionally alters one or more factors under controlled conditions then study the effects from doing so. However, the inclusion of this classification within epidemiology design is debatable and will be discussed in the following section.

'Distribution' refers to how the amount or burden of risk factors and/or outcomes is distributed in a specified population, including analysis of: times, persons, places and classes of people affected.

‘Determinants’ refers to causal factors that influence health. These factors include biological, chemical, physical, social, cultural, economic, genetic and behavioural types.

‘Health-related states and events’ refers to having a condition or experiencing a new event. This includes diseases, causes of death, behaviours such as use of tobacco, reactions to preventive regimens and provision, positive health states and use of health services.

Specified populations include those with identifiable characteristics, such as occupational groups. The results should be applied to inform and guide public health actions, which aim to promote, protect, and restore health (this is part of the public health roles).

A single epidemiological study rarely provides proof of a causal relationship (Rothman, 1988). One of the key points of discussion is whether epidemiology uses or should use the same criteria for the ascertainment of cause-effect relationships as used in other sciences. Several authors have discussed causality assessment in epidemiology (Hill, 1965; Rothman, 1988; Weed, 1986). Hill’s criteria (Hill, 1965), nonetheless, are the most widely used. He proposed the following nine considerations for establishing such a relationship:

1. Strength of association: a strong association is more likely to have a causal component than is a modest association.
2. Consistency of the observed association: has it been repeatedly observed by different persons, in different places, circumstances and times? The benefit is to reduce the probability that an association would be due to a constant error or fallacy in the same study design.
3. Specificity of the association: if one observed an association that was specific for an outcome or group of individuals, this was a strong argument for a causal effect.
4. The temporal relationship of the association: the cause must precede the effect. To illustrate this, Hill asked whether a particular diet triggered a certain disease or whether the disease led to subsequently altered dietary habits. According to Hill, temporal direction might be difficult to establish if a disease developed slowly and initial forms of disease were difficult to measure.
5. Biologic gradient (a dose-response relationship): an increasing amount of exposure increases the risk.
6. Plausibility: the relationship agrees with currently accepted theoretical basis of pathological processes.
7. Coherence: the relationship should be consistent with existing theory and knowledge.

8. Experimental evidence: the condition can be altered by an appropriate experimental procedure.
9. Analogy (considering other similar known relationships): when something is suspected of causing an effect, other factors similar to the anticipated cause should also be measured and identified as a possible cause or eliminated from the investigation.

1.3.4 Epidemiological Designs

As the society becomes better informed about ill-health and well-being, there is a need for more sophisticated and complex epidemiological methods to understand the contribution that different factors (e.g., environmental, genetic, behavioural) make to health and well-being. Hence, epidemiological methodology is continually changing as it adapts to a greater range of health problems and more techniques are borrowed and adapted from other disciplines such as mathematics, statistics, and biomedical sciences (Stewart, 2002).

Epidemiologic studies are conducted to measure disease occurrence and to identify associations between exposures and health outcomes. However, one way to achieve this is to consider their role within public health. Generally, epidemiological studies are employed to provide information on the following areas (Carr et al., 2007):

- on the distribution and frequency of diseases and known and possible causes of diseases in populations; such studies are usually called descriptive;
- on the strength of associations between diseases and other factors (e.g., smoking), with particular emphasis on whether such associations are causal; such studies are usually called analytical;
- on evaluation of interventions aimed at preventing a disease or improving its outcome, such studies are usually called intervention studies, as well as, health impact studies, which evaluate interventions, but necessarily via employing experimental designs.

Descriptive studies include routinely collected and reported data on mortality, morbidity, and related factors. Analytical studies are based on hypothesis testing, where researchers attempt to quantify the relationship between the effects of an exposure on an outcome, and include observational studies such as ecological, cross-sectional, case-control, and cohort. Intervention studies focus on interventions and outcomes attempting to determine their associations (i.e., the researcher manipulates the exposure by allocating subjects to the intervention); such studies include the clinical trial, and community trial.

Nonetheless, in the textbook, ‘Research Methods in Occupational Epidemiology’ (Checkoway et al., 2004), which is solely dedicated to discussing occupational epidemiology methods, interventional studies (i.e., randomised controlled trials) have been excluded from the occupational epidemiology designs; unlike several other general epidemiology textbooks (Bonita, Beaglehole, Kjellström, & Organization, 2006; Carr et al., 2007; Last, 2000). Furthermore, Pearce (2005) commented on Last’s (2000) definition of epidemiology as being too broad, since it could include a range of research methodologies including randomised controlled trials. He argued that, although some epidemiologists include randomised controlled trials in the definition of epidemiology:

‘the key feature of epidemiological studies is that they are quantitative (rather than qualitative) observational (rather than experimental) studies of the determinants of disease in human populations (rather than individuals)’ (Pearce, 2005, p. 9).

This argument is adopted in this research programme when referring to epidemiological research.

On the other hand, it is worth noting that the focus of clinical epidemiology, which is the application of epidemiological principles and methods to the practice of clinical medicine with an emphasis on diagnosis, prognosis and treatment (Parfrey & Barrett, 2009), is on the following (Haynes, 2006):

- definitions of normality and abnormality
- diagnostic tests accuracy
- natural history and prognosis of disease
- effectiveness of treatment
- prevention in clinical practice.

It is clear from the above points that clinical epidemiology deals with patient populations rather than community-based populations, and that it is usually conducted by clinicians in a clinical setting. Thus, it is often omitted from the definition of epidemiology and for these reasons it has been decided that it would be excluded from the current study analysis.

Miettinen *et al.* (2009, p. 1212) noted that:

‘... epidemiological research has almost exclusively been in the service of population-level preventive medicine; and to this end, it has almost entirely been research on the etiology ...of illness, not research on actual preventive interventions.... Thus, only in research to advance the knowledge base of etiognosis (knowledge of the role of a potential cause, not the potential cause

itself) should clinical researchers look for guidance from the theory of epidemiological research...'

This leads to a conclusion that, at large, epidemiological studies (particularly that investigating occupation related issues as can be seen in section 1.3.5); do not tend to focus on patient-populations, are mostly observational in nature, and rarely employ interventional studies. Therefore, both clinical epidemiology and interventional studies will be excluded from the analysis in the current study.

1.3.5 Public health epidemiology

There is no standalone definition for public health epidemiology (PHE). Most authors define public health and epidemiology separately and then refer to epidemiology as the core science of public health that informs and guides its activities (Savitz et al., 1999).

There are many definitions for public health and epidemiology. However there is confusion about their definitions, and about epidemiologic studies classifications (Pearce, 1999; Savitz et al., 1999). This confusion is, probably, because both fields are continually adapting and evolving due to the continuous and rapid advances in health and other scientific fields (Pearce, 1999). For instance, due to advances in genetics and molecular sciences, new tools and methods have been developed and employed in the epidemiological field. Another reason might be due to the fact that public health epidemiology research is multidisciplinary and relies on diverse domains of expertise. For example, an epidemiological study might require a clinician, statistician, biologist/toxicologist, and an exposure scientist. These scientists/practitioners might call themselves epidemiologists; and thus they are likely to define epidemiology by taking into considering their own perspectives, and their own fields' theories and practices.

Thus, all epidemiological sub-disciplines, in the short or long term, aim to improve the health of the public, and inform public health decisions, come under the general term "public health epidemiology". Regardless of the focus of a given study, the epidemiological principles applied to investigate disease-exposure associations are the same (Silman & Macfarlane, 2002). Public health epidemiology hence encompasses a wide variety of study areas. Much of the work which is currently being done under the headings of, for example, infectious disease epidemiology, occupational epidemiology, environmental epidemiology, nutritional epidemiology, and molecular epidemiology, is essentially relevant to public health. Epidemiologists working in these areas have established themselves as members of different subspecialties (Mackenbach, 1995).

Based on the above discussion, and for the purpose of this programme of research, PHE can be defined as one of the core sciences for the investigation of the distribution and determinants of health-related states or events in specified populations (Last, 2000).

1.3.6 Specific features of occupational epidemiology

There are significant commonalities between the basic concerns of various epidemiological sub-disciplines. In occupational epidemiology; however, there are specific features that differ from the general PHE.

1) The healthy worker effect

The health of workers is subject to normal health threats for the adult population, but there are specific threats to health associated with the work situation. Workers have lower death rates from the general population because they are demographically different from the general population and even epidemiologically different from a population matched for age and sex (McMichael, 1976). This is due to the fact that there is a process of selection of workers that excludes the severely ill and disabled from employment.

The selection process continues with attrition of unhealthy persons from the workplace. This is termed the healthy worker survivor effect and is a factor to be considered in OE studies (McMichael, 1976). Thus, the possibility for detecting certain health risks may be lower than if the study was conducted in a general population (Checkoway et al., 2004; Silman & Macfarlane, 2002). Death rates or other population-based norms from the general population may be inappropriate for comparison if this effect is not taken into account (Shah, 2009).

In contrast, PHE studies would normally include children, elderly and sick people (Carr et al., 2007). This is important when the results of OE studies are used to establish safety standards for specific environmental hazards. Exposed people in the general population are likely to be more sensitive than workers in industry. For instance, the effects of lead occur at lower exposure levels in children than in adults. It is also rare that an alternative comparison group, such as another worker population, is available. Sometimes, however, healthy worker selection bias is minimised by using a non-exposed comparison group drawn from within the study working population and high exposed can be compared to lower-exposure (exposure-response) (Checkoway et al., 2004).

2) Level of exposure

Dose-effect and dose-response relationships are of particular importance in occupational epidemiology because they provide the basis for establishing safety standards. Some diseases and their related risk factors rarely occur in non-occupational settings, such as pneumoconiosis in coal miners. Furthermore, because exposures are often higher in the workplace and frequently are better characterized there than in the general environment (Ramachandran, 2005), harmful work exposures can, theoretically, be considered as a 'natural experiment' in the causation of illness and injury (Rushton, Hutchings, & Driscoll, 2013). The dose-effect relationship can be used to decide which effect is most important to prevent. Once a decision is made, concerning an acceptable response level, the dose-response relationship gives the maximum dose that would be acceptable (Ramachandran, 2005). Thus, the study of these can illuminate the causes and prevention of diseases and injuries in general (Rushton, Hutchings, & Driscoll, 2013).

1.3.7 Cancer epidemiology

Cancer epidemiology is a branch of epidemiology that studies factors influencing the occurrence (e.g., incidence, population distribution) of neoplastic and pre-neoplastic diseases and related disorders (Last, 2000). Primary outcomes include incidence, prevalence, survival, and mortality from all types of cancers (Last, 2000). Thus, cancer epidemiology focuses not only on cancer, but also on precursors of cancer (e.g. chronic atrophic gastritis as a precursor of stomach cancer).

1.3.8 Molecular and Genetic epidemiology

There are some perceived weaknesses of epidemiological studies. This is mainly due to its observational nature, which may lead to bias, the frequent inability to replicate associations across studies, and the inability to adjust for all potential confounding factors (Parfrey & Barrett, 2009). Despite these, epidemiologic methods have grown steadily over the past thirty years and have become increasingly integrated with genetics and molecular biology in the disciplines of genetic and molecular epidemiology (Khoury et al., 2010; Teare, 2011b).

Molecular epidemiology was proposed by Perera and Weinstein to enhance the traditional epidemiological design through the incorporation of laboratory analytical techniques to elucidate the biochemical or molecular basis of exposure and disease aetiology (Perera & Weinstein, 1982). Since then, many epidemiological studies have been conducted, which have incorporated molecular biology (Bonassi et al., 2005).

Similarly, another new approach, namely genetic epidemiology, has been developed. This deals with the aetiology, distribution, and control of disease in groups of relatives, and with inherited causes of disease in populations (Carr et al., 2007; Teare, 2011b). It aims to establish a genetic component to the disorder, the relative size of that genetic effect in relation to other sources of variation in disease risk, and the responsible gene(s) (Carr et al., 2007).

The factors that distinguish genetic and molecular epidemiology are both: the “genetics and molecular,” the use of the techniques of genetics and molecular biology to characterise nucleic acid or amino acid-based content; and the “epidemiology,” the study of the distribution and determinants of disease frequency in populations (Foxman & Riley, 2001). Molecular markers can be markers of exposure or predeterminants of disease.

1.4 Motivation for the study

The initial motive behind this study was the difficulties in carrying out health research in the UK due to the challenges imposed by the current ethical and governance frameworks and a perceived lack of funding. Many authors trying to undertake studies using a range of different designs have claimed that ethics and governance regulation is impeding health research in the UK (Campbell, Bagley, Van Heest, & James, 2010; Coggon, 2001a; Cook et al., 2007; Elwyn, Seagrove, Thorne, & Cheung, 2005; Hewison & Haines, 2006; Leeson & Tyrer, 2013; Lux, Edwards, & Osborne, 2000; Snooks et al., 2012). This includes epidemiological studies and randomised controlled trials (RCTs).

These difficulties can be major obstacles for conducting low risk epidemiological studies and particularly OE research. OE research has several unique features that make it more susceptible than other types of research to such challenges and therefore was selected as an exemplar where these issues would be explored. Furthermore, these regulations apply a level of governance based on studies of diseased patients with experimental treatments that it is not appropriate for occupational studies. Potential study participants are often in distinct organisations and sites, and, therefore, procedures to safeguard confidentiality may need to be more stringent than those for general population studies. New challenges are also encountered when different stakeholder groups are involved in research studies (e.g., union representatives and industry management), especially in gaining access to information and participants (Checkoway et al., 2004). Therefore, participation in a study, and the impact of results, can be interwoven with situational power dynamics and the hierarchical relationships of the workplace.

Furthermore, there are various potential information sources for data used in OE studies including (Checkoway et al., 2004; Taskinen, 1993):

- Diseases data sources, which are common sources for both OE and other types of health research
 - Mortality data (National Health Service Central Register (NHSCR), and company records and pension records)
 - Cancer registration data (NHSCR, occupational health, and GP records)
 - Other sources of diseases of interest (medical examinations and/or questionnaires)
- Occupational exposures sources, which are common sources for mainly OE studies
 - Company records
 - Hygiene assessments
 - Questionnaires (from participants and work colleagues)
- Other exposures and factors of interest
 - Questionnaires (from participants and family members)
 - Occupational Health records (mainly for OE studies)
 - GP/Hospital records

Clearance is required to obtain the data from each of these sources. This includes overall ethical and governance approvals, permissions from management and the workforce representatives at the industry, and potentially individual consent from the subject or their next of kin (if subjects are dead). The nature of the required consent varies according to the type of the study, and to other factors such as how much support is received from the management (including OH department if present) and workforce representatives. Accessing such data and workers records particularly for those who have left or died, for research purposes can be difficult and occasionally impossible for similar legal and legislative reasons and for fear of future litigation in relation to record access or research findings (Cowie, Creely, K, & Miller, B G, 2005). Furthermore, even when data are anonymised and thus linkage is possible; data linkage errors can occur, which may introduce bias into statistical analysis (Hagger-Johnson et al., 2015).

Another important factor for conducting OE is the existence of occupational records for workers exposed to new or currently unknown hazards (Lightfoot et al., 2003); however the existence and completeness of these records are entirely dependent on the standard practices of a particular company or employer. Some companies would prematurely destroyed the workers' records (Rushton & Betts, 2001). Assessing the availability, completeness and

accuracy of information required for the study prior to the study being carried out is a viable approach (Checkoway et al., 2007). However, it is not always practically possible to assess the information sources for completeness and accuracy prior to the study due to access restrictions and confidentiality laws (Coggon, 2001a).

In summary, researchers are not allowed to access such data sources and participants unless they have obtained relevant stakeholders approvals (e.g., management or employer, relevant ethical committee approvals, and governance clearance) and addressed legal requirements regarding data registers and storage; confidentiality of data provided to the study direct by the subject; and access to data held on the study participants by other sources (Coggon, 2001a; Cowie et al., 2005). However, ethical and governance regulations are designed for high-risk studies, which use medical interventions on primarily patient population. These regulations are imposed at a similar level to OE studies despite the fact that they are primarily observational in nature and are considered low-risk studies in terms of potential harm to participants. The Health Research Authority introduced the Proportionate Review Service (PRS), under which research studies which raise no material ethical issues will be reviewed by sub-committee rather than at a full meeting of a REC with an aim to make a decision within 14 days of the research proposal application (Health Research Authority, n.d.). However, this is currently utilised in Scotland, but not in England and Wales (D. McElvenny, personal communication). The eligible studies for PRS are primarily those that use anonymised data, utilised no linkage to patients' identifiable data and those that use questionnaires or interviews that are not sensitive in nature. Nonetheless, these key criteria are not generally applicable to most epidemiological studies.

On the other hand, from an early stage of this study (i.e., the interview phase), challenges due to ethics and governance frameworks were found to be less important than other key issues identified in the study. Therefore, the focus of the programme was shifted in the second stage of the study (i.e., in the bibliometric and documentary review phases) to explore other more important issues and specifically relevant to OE field.

1.5 The study aims and objectives

The overall aims of this thesis are: to identify the current challenges to and facilitators of the OE field in the UK; to identify the external social, political, economic and any other factors which frame and contextualise these challenges and facilitators; to use this contextualisation to explain and evaluate how and why the identified challenges and

facilitators influenced the OE field development compared to other similar fields; and to illuminate what OE and other health research fields can learn to optimise their future development.

The study is divided into two parts consisting of four phases in total. Figure 1-1 provides an overview of the PhD research phases and Table (1-1) summarises the aims and objectives of each phase.

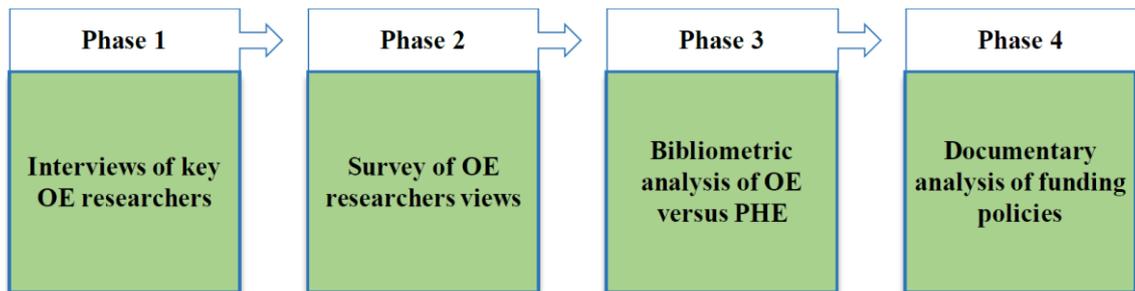


Figure 1-1: An overview of the phases of this PhD research programme

The first part was designed to identify and examine the challenges to and facilitators of OE research in the UK, the impact of these, and the strategies employed to overcome the challenges. It comprises of two phases: (i) a qualitative interview study of key UK-based OE researchers to explore their perceptions and experiences of these issues; and (ii) a survey of the broader OE community to assess whether the issues identified in the first two phases are similar, and to identify any other issues (if any).

Table 1-1: Aims and objectives of each phase of the thesis

Aims	Objectives
Phase 1: Interview and survey	
<p>To explore the current challenges and facilitators of occupational epidemiology research in the UK with a view to assessing the impact of these challenges and any strategies employed to overcome the challenges.</p>	<p>1- Explore key researchers' perceptions of OE research challenges and facilitators, the impact of the challenges, and strategies developed to overcome the challenges; 2- Assess whether the issues identified by key researchers and found in the literature are similar or different to those perceived by the wider occupational epidemiology community in the UK; and 3- Explore any other effects of the identified challenges on the participants' research studies.</p>
Phase 2: Bibliometric study	
<p>1- To analyse the characteristics of the OE literature over a defined period of time and compare it with the PHE literature, in the field of cancer epidemiology; 2- To identify any emerging patterns or trends in both fields and explore the likely reasons for differences that might emerge from the data; and 3- Identify any external social, economic and political factors that could explain the trends and the difference in the trends between OE and PHE fields.</p>	<p>1- Quantify and compare OE and PHE research outputs over time, in the field of cancer epidemiology, and identify temporal evolution of scientific productivity (i.e., time points where low or high levels of publications are identified); 2- Explore other publication trends; for example number of authors and quality of publications (i.e. article citation scores and Journal impact factors); 3- Identify possible factors contributing to the variations in publication trends including research collaborations and funding; and 4- Identify time periods characterised by key differences in publication trends between OE and PHE, and consider the key external factors that could have influenced these differences.</p>
Phase 3: The documentary analysis	
<p>1- To explore health research funding mechanisms and policies of key UK biomedical and health research funding bodies including their role in the allocation of research funds and their relation to the development (or lack of it) of certain health research fields; 2- Identify any external social, economic and political issues that might have influenced the decisions and policies of these funding bodies; and 3- To examine how these issues could explain further how relevant challenges and facilitators in the OE field have evolved compared to other health research fields.</p>	<p>1- Elucidate the process or procedures employed by funding bodies in research funding allocation and justification of the allocation of funds; 2- Understand why funding schemes of particular programmes are initiated and ended; 3- Examine the role of certain policies, leadership issues; including those of the funding bodies and the recipients of the funds (i.e., researchers); 4- Identify any external issues; such as social, economic and political factors, and discuss the potential influence of these on funding decisions and policies of these bodies; 5- Explore the relationship between funding and research collaboration, as well as, the use of new methods and techniques; 6- Discuss the implications of the findings in relation to further understanding of the challenges and facilitators of the OE field as well as other health research disciplines.</p>

The first two phases, in the first part of the study, complemented each other and helped to identify the key challenges and facilitators to be explored in the second part of the study, which comprises the third and fourth phases. The third phase was designed to achieve three key aims; (a) to confirm the current challenges and facilitators experienced in the OE field that were identified in the first part of the study; (b) to examine whether these are also experienced in other similar fields; and (c) to identify time periods over which research activity in these similar research fields might have diverged from that in the field of OE, as a basis for further investigation of the possible social, economic, political and other possible issues on this divergence. To address these aims, phase three consisted of a bibliometric analysis of OE publications in comparison to those in Public Health Epidemiology (PHE) in the field of cancer, and phase four consisted of a documentary analysis of key research funding bodies' annual reports to explore the funding bodies' policies and funding mechanisms in relation to the development (or lack of it) of certain health research fields (including OE).

1.6 Organisation of the thesis

The structure of the thesis is made up of eight chapters: the introduction; the background and context; the systematic review; the research methodology; the challenges to and facilitators of OE research in the UK; the trends in the development of OE relative to PHE; the impact of funding policies, and the discussion and conclusions.

The first section of the thesis is a general introductory chapter, Chapter 1. The chapter begins with introducing the thesis topic and purpose of this research programme. This is followed by definition of key terms, motivation for the study, aims and objectives, organisation of the thesis, and ends with a brief summary.

Chapter 2 sets the scene by providing a background of the historical development of OH and safety, OM, and research within these in the UK and highlights key policies and issues that influenced their development. These include the exclusion of the OH from the NHS, education in OM, changes in the higher education system, and deindustrialisation. Furthermore, similar relevant issues, notwithstanding to a lesser scope, in relation to the public health field and public health medicine are also discussed. Finally, medical workforce issues within both OH and PH fields are discussed, which provided an important background in terms of the development and capacity of research workforce in both fields.

Chapter 3 presents the systematic review designed to explore any reported OE field challenges and facilitators. It includes systematic databases searches to identify primary research reports, and key journals hand-searches to identify original OE studies' reports to assess whether researchers mentioned any issues within these.

Chapter 4 discusses the philosophical underpinning of the research methodology and design used to carry out this research programme as well as the rationale behind those decisions. This includes an overall discussion of the mixed-methods design used in this study, which comprised the four phases identified in section 1.5 and carried out from 2010-2014. The chapter ends with the ethical considerations of this research programme.

Chapter 5 presents the methods, results and discussions of the first two phases of this research in three parts. Part one describes semi-structured interviews with UK-based key OE researchers (phase 1). Part two discusses a questionnaire survey of the wider UK based community of the OE field (phase 2). Part three presents overall discussion of these two phases and how their findings informed the research direction and designs of the last two phases (phases 3 and 4).

Chapter 6 presents the third phase of this research which comprises a bibliometric analysis of UK publication trends of cancer studies in the field of OE compared to PHE. The chapter includes the methods, results, and discussion sections. The chapter reports findings from the first two phases and identifies key research areas (research funding policies and allocations). The results of this chapter have merited further investigations and informed the design of the final phase of this research programme.

Chapter 7 represents the final phase of the study (phase four), which discusses the documentary analysis study. This includes the type of documents and selected period for study, the results, and discussion of findings.

Chapter 8 provides an integrated final discussion of the findings from all the four phases of the research programme and explains how the objectives of the research have been met in relation to the challenges and facilitators of OE research in the UK. It also discusses the impact of these findings on the rise and fall of this field as well as on other relevant health research disciplines.

1.7 Summary

This chapter introduced the topic of this thesis and provide a brief background. This was followed by a discussion of key terms definitions including the OE definition and its role in improving the health of the workforce. The motivation behind the study was highlighted followed by an outline of the aims of the research and structure of the thesis. Chapter two presents the background and context of this thesis by reviewing relevant literature and policy documents.

2 BACKGROUND AND CONTEXT

2.1 Introduction

In order to explore the current issues facing the OE field in the UK, as briefly highlighted in the previous chapter, it is vital that the background and context in which this field has developed is understood. Major historical trends over the last few decades have conspired to reshape OH and OM, trends that, if understood correctly, can help to more accurately assess the current challenges and facilitators of the OE field. OE is predominantly a research method within the field of OH that has made an important contribution to the development of OM, and therefore also to the improvement of the health of the working population (Checkoway et al., 2004a). Thus OH, OM and OE are inextricably interwoven and one cannot be established or developed without the other. For instance, occupational physicians are the key drivers of OH of the workforce. The vast majority of OE studies hence require both the occupational physicians' and the workers' participation to be successfully undertaken.

In this chapter, a discussion of the issues that are most relevant to this research is presented. These include the historical development of occupational health and safety in the UK, and how the current system of health and safety in the UK has evolved by highlighting key milestones, events, and the context in which these were created. Similarly, the development of OM is then discussed starting from the establishment of the certifying surgeons until the establishment of the most current role of OH consultant. This is followed by a section discussing the development of research in the OH and safety and identifying key data sources in this field. Key issues that influenced the development of OH and ultimately affected both the development of OH and OE in the UK are subsequently presented. These include the exclusion of the OH from the NHS, education in OM, changes in the higher education funding system, and deindustrialisation. Furthermore, similar relevant issues, albeit to a lesser scope, in relation to the public health field and public health medicine are also discussed. This is because in the bibliometric study and, to some degree, in the

documentary review phases of this research, key issues within the OE field were compared to those within the field of PHE. The final section discusses the medical workforce issues within both OE and PHE fields, which provided an important background information in terms of the development and capacity of research workforce in both fields.

2.2 The development of occupational health services in the UK

2.2.1 Historical background

In Britain, the Industrial Revolution began in the mid-eighteenth century; scientific innovations and technological improvements contributed to the advancement of agriculture, industry, shipping and trade and to the expansion of the economy (Hobsbawm, 1999; Thompson, 2013). The industrial and economic developments of the Industrial Revolution brought significant social changes (Hartwell, 1971). With the progress of industries, more people moved to settle near the source of power in the industrialised cities and by the end of the nineteenth century there was enormous change on the existent social, economic and cultural features of the country (Hobsbawm, 1999; Thompson, 2013).

A growing number of people moved to urban centres in search of employment, and this resulted in an increase in population and urbanisation (Hobsbawm, 1999; Thompson, 2013). Some individuals became very affluent; however, some lived in atrocious conditions. A class of wealthy industrialists, ship owners and merchants dominated, amassing great wealth, but at the same time the working classes had to live with minimum reliefs in overcrowded environments (Braun & Tenison, 2005). Children were sent to work in factories, where they were exploited and mistreated; women experienced significant changes in their lifestyle as they took jobs in domestic service and the textile industries, leaving the agricultural workforce and spending less time in the family home (Braun & Tenison, 2005). This period also saw the creation of a middle class that enjoyed the benefits of the new prosperity (Hartwell, 1971).

In addition, Britain in the late 18th and 19th centuries experienced political unrest as the industrialisation and urbanisation of the country created a need for social and political change (Hopkins, 2013). There were growing demands for improved social welfare, labour rights, education, changes in the electoral system, political rights and equality (Hopkins, 2013).

Engels, in his book “The Condition of the Working-Class in England in 1844” (Engels & Wischnewetzky, 2010), described the extreme environmental and health conditions and the

distress experienced by the working class, as well as the lack of state intervention to alleviate their situation:

'That a class which lives under the conditions already sketched and is so ill-provided with the most necessary means of subsistence, cannot be healthy and can reach no advanced age, is self-evident.... They are given damp dwellings...They are supplied bad, tattered, or rotten clothing, adulterated and indigestible food. They are exposed to the most exciting changes of mental condition, the most violent vibrations between hope and fear; they are hunted like game, and not permitted to attain peace of mind and quiet enjoyment of life. They are deprived of all enjoyments except that of sexual indulgence and drunkenness, are worked every day to the point of complete exhaustion of their mental and physical energies, and are thus constantly spurred on to the maddest excess in the only two enjoyments at their command. And if they surmount all this, they fall victims to want of work in a crisis when all the little is taken from them that had hitherto been vouchsafed them. How is it possible, under such conditions, for the lower class to be healthy and long lived? What else can be expected than an excessive mortality, an unbroken series of epidemics, a progressive deterioration in the physique of the working population?' (Engels & Wischnewetzky, 2010, pp. 106–107).

He then provided statistics of mortality rates from official documents as evidence for his arguments. For instance, he stated that the annual death rate of England and Wales for the years 1839-41 was less than 2.25%; one death per 46 people (Engels & Wischnewetzky, 2010). However, in heavily industrialised cities, the mortality rates were as follows: in Manchester one person died out of 32.72 people; in Liverpool one died out of 31.90 persons, in Cheshire, Lancashire, and Yorkshire one death in 39.80 persons; in Edinburgh, one death in 29 persons; in Glasgow, one death in 30 persons (Engels & Wischnewetzky, 2010).

This period of great social distress and economic turmoil caused a national outcry from social reformers and philanthropists (including amongst others; Robert Owen, Charles Turner Thackrah, Michael Thomas Sadler, and Richard Oastler) who advocated the cause of, in particular, the improvement of the condition of children employed in factories (Burwick, 2015). As a result of philanthropic pressure particularly when the interest of the employing class was threatened, the State took action (Smiley, 1971). For example, when an epidemic disease started in a cotton mill in Manchester (threatening the health of the employing class and production), Dr. Thomas Percival was appointed in 1784, to investigate this epidemic (Hutchins & Harrison, 2009; Smiley, 1971). For the purpose of his

investigation he established the Manchester Board of Health. The reports of this Board recommended the establishment of isolation hospitals, the need for the improvement of the environmental conditions in mills and factories, and the reduction of working hours particularly for children and women.

One of the earliest government legislations to control child labour and to establish health and safety measures was the Chimney Sweepers Act of 1788, which came as a result of Percival Pott's findings on the subtle effects of soot on chimney sweepers, which found to be causing a scrotal cancer (Hutchins & Harrison, 2009). The most important government legislation however, was the first Factory Act "the Health and Morals of Apprentices Act 1802", which was introduced to address the Manchester Board of Health concerns (Smiley, 1971). This Act established the right of the State to intervene in the regulation of employment in factories (Hutchins & Harrison, 2009). From this first Act, the principles of factory legislation were laid down, that is to protect and educate vulnerable workers. These vulnerable workers were defined as children, young persons and women. Subsequently, factory legislation would become of the most comprehensive domains of government growth throughout the nineteenth century.

However, as noted by Smiley (1971, pp. 317), "The 1802 Act...was observed mainly in the breach and there is considerable evidence not only that many magistrates were unaware of its provisions but that the visitors when appointed, being usually derived from the social class of the employers, performed their duties in a most perfunctory manner. Nevertheless its enactment was of great importance for it re-established that the State had a right, indeed a duty, to supervise factory life". By the 1830s the debate over working conditions intensified culminating in the Factories Act of 1833 which could be argued to be the first effective law in the field of industrial safety in the UK (Hutchins & Harrison, 2009; Thomas, 1948). From the 1830s onwards factory legislation was gradually extended, in the textile industries first, to regulate the hours of work for this group of workers, to restrict the age at which young children could be employed, and to provide education for factory children (National Occupational Safety and Health Committee (NOSH), 2016).

Subsequently, factory legislation was extended to mines in 1842. By the 1860s this legislation was extended to non-textile industries, and the first regulations for dangerous trades and machinery were introduced at that time (Hutchins & Harrison, 2009). Mines were regulated separately, though the mining regulations followed a similar schema (Hutchins & Harrison, 2009). The inclusion of workers in the 'dangerous trades' began with

the introduction of special rules in the white lead industry in the 1880s, to reduce the high prevalence of cases of lead poisoning associated with the industry (Henriques, 1971). The Poor Law Guardians of Gateshead had petitioned the Home Office to examine the number of cases of lead poisoning occurring among workers in the nearby white lead works which, they claimed, created an unfair burden on the ratepayers (Rowe, 1983). The succeeding investigations into lead poisoning in the white lead industry stimulated interest in other industries which utilised lead (Rowe, 1983).

Meanwhile legislations for non-factory workers in transport, agriculture, shops and offices were slowly following the Factory Acts. The Factory Act of 1891 included clauses that referred explicitly to occupational health, and enabled the Home Secretary to schedule trades or processes that had been shown to be dangerous to life or limb (Hutchins & Harrison, 2009). Once an industry or a process was prescribed as dangerous, special rules were then introduced to regulate these harmful trades. The first dangerous trades to be scheduled were those that utilised a number of hazardous substances, namely; lead, phosphorus, mercury, and arsenic (Henriques, 1971; Hutchins & Harrison, 2009). Processes where workers were exposed to anthrax also came under the category of dangerous trades. Notification of these industrial diseases was introduced in the 1895 Factory Act (Hutchins & Harrison, 2009).

2.2.2 Compensation

The introduction of compensation was also a landmark in the development of industrial legislation, occupational medicine and the legislation of industrial relations, which also reversed the situation regarding employers' liability (Bartrip, 1987; Henriques, 1971). The idea of worker compensation was first introduced by Chadwick, a public health reformer and Poor Law commissioner, due to reports of doctors to Chadwick about the appalling conditions of work of the railway workers. Chadwick, in his paper titled "*On the Demoralization and Injuries*", advocated the burden of compensation as a means of accident prevention (Lee, 1973).

That paper caused a parliamentary enquiry into the working conditions of railway labourers (Lewis, 1950). The committee recommended not only making the railway companies pay compensation for accidents but also promoted the power of the purse as an incentive to accident prevention (Lee, 1973). This proposal was only an extension to the 1844 Factory Act that in case of injury to any one from unfenced machinery the whole or part of the penalty may be applied for the benefit of the injured person (Lee, 1973). Later in 1897, the

Workman's Compensation Act was introduced, which gave, for a large group of workers, statutory rights to claim compensation for an accident, regardless of whether the employer or, to a large extent, the worker was at fault (Hutchins & Harrison, 2009). In 1906, the schedule of this Act was extended to incorporate compensation for certain industrial diseases (Bartrip, 1987).

Doctors began to work in the industrial setting at this time to assess eligibility for worker's compensation. They were not well regarded by the workers, who saw them as a tool of management. Recognising the need for standards and best practice among doctors working in the industrial setting, the Association of Industrial Medical Officers was founded in 1935. By 1967 the Association became the Society of Occupational Medicine to reflect the change in the nature of the workplace and the work of the medical officers which had been concerned originally with the diseases arising from industrial processes but gradually covered other types of work (Fingret, 2000).

2.3 The development of occupational health medicine

Throughout the nineteenth century, the development of occupational medicine was most closely associated with that of public health medicine. The mid nineteenth century factory reformers based their views on occupational diseases on contemporary sanitary science, and directed their attention to environmental and sanitary problems within factories, such as hours of work, ventilation, fencing dangerous machinery and sanitary inspection (Schneider & Lilienfeld, 2011). The control of specific occupational diseases, and the concern of doctors with these illnesses, did not develop until the end of the nineteenth century (Hutchins & Harrison, 2009). The Factory Acts of the first half of the century were specifically concerned with the effect of employment on children's and women's health, and the regulation of their hours of work. Though not directly concerned with occupational disease, they did engage the opinion of the medical profession over dangers to health inherent to industrial labour (Lewis, 1950).

Charles Turner Thackrah was the first to establish the idea of occupational medicine as a specialty in the UK and to draw the attention of the public to occupational diseases (Meiklejohn, 1957). His contribution to this field was evident in his 1830 seminal publication *“The Effects of Arts, Trades and Professions and of Civic States and Habits of Living, on Health and Longevity, with Suggestions for the Removal of Many of the Agents which Produce Disease and Shorten the Duration of Life”* (Meiklejohn, 1957). The legislative drive to regulate child labour did involve the medical profession in the

administration of the Factory Acts. Shortly after his publication, the Factory Act of 1833 required that a surgeon should certify that a child was of a strength and appearance of nine years old (Fingret & Smith, 2013). This was needed because the compulsory registration of births did not become effective until 1837 (Smiley, 1971).

2.3.1 The Certifying Surgeons

In 1844, the 1833 Factory Act was modified to include the appointment of specialised certifying surgeons whose role was to examine young entrants to industry to certify that they were nine years old or above. Certifying surgeons' positions later came under much criticism from manufacturers. The surgeons were accused of overcharging for their service, for making unnecessary visits, and occasionally for misconduct (by receiving bribery for approving unfit/younger children to be fit for work) (Bloor, 1981; Smiley, 1971). The surgeons also came into conflict with the sub-Factory Inspectors over the appropriate duties given to the two professions (Lee, 1973).

This debate led Dr Robert Baker to urge the surgeons to provide public evidence of their contribution to improved factory conditions. In response to Baker's suggestions, the Association of Certifying Medical Officers was formed in 1868 (Bloor, 1981). The Association had 300-400 members out of the 900 certifying surgeons at the time (Bloor, 1981). The aims of the Association were twofold; first to promote the advance of sanitary science and the relief and prevention of disease incident to the various processes of manufacture, and second, to consolidate and improve the certifying surgeons' position in relation to the government and the public (Bloor, 1981). The second aim of the Association was achieved when the Factory and Workshop Act of 1878 confirmed the officer of certifying surgeons. Lee (1973) argued that because the consolidation and improvement of the position of the Certifying Surgeons, had been achieved, there was not sufficient interest to keep the Association going in order to further its first aim.

The dangerous trade legislation of 1891 directed the focus of the Factory Inspectorate towards working conditions of scheduled trades. With the increasing awareness of industrial diseases, these inspectors were closely associated with the campaign against industrial diseases and the prevention of these. Subsequently, an entirely new measure of control was introduced in the 1895 Factory Act, through the compulsory notification by medical practitioners and the factory occupier of four industrial diseases: lead, arsenic, and phosphorus poisoning, and anthrax (Lee, 1973). This led to another important development in 1898, when medical inspectors were added to the factory inspectorate and Dr Thomas

Legge was appointed the first Medical Inspector, succeeding by Dr Robert Baker in the following year (Meiklejohn, 1956).

Certifying surgeons were also involved in the monitoring of occupational health. Initially appointed to authorise the employment of children, by the twentieth century their duties were extended to include the examination of workers employed in the dangerous trades. In 1937 they became the examining surgeons, which was changed again in 1948, through an amending Act, to that of appointed factory doctors (Young, 2013). This Law continued until it was replaced by the current Employment Medical Advisory Service Act of 1972 (Lee, 1973).

2.3.2 Research in occupational health

The development of OH was neither entirely directed by manufacturing interests, nor did it result from the objective analysis of industrial hazards. Rather, the political implications arising from the medical recognition of occupational diseases, dominated both the introduction of legislation and the subsequent application of medical knowledge (Carter, 2000). The analysis of OH demonstrates how this was realised through the mediation of different interest groups. In that respect, for instance, medical evidence in occupational health, particularly that of epidemiology, had played a key part in the trade unions movements to improve the health of the working population; by influencing policy making developments (Long, 2011; McIvor, 2012).

The development of occupational medicine, including research was substantially fostered by the political circumstances in the UK during the interwar period (Long, 2011). During World War I, pressure developed to increase industrial output (Burnham, 2009). In an effort to maximise munitions production, the British government set up a Health of Munitions Workers Committee in 1915 to investigate the subject of Industrial Fatigue with regard to industrial efficiency and to the protection of health among the workers; particularly women workers (Fingret, 2000). The Committee encouraged research into workers' health and environmental conditions that affected their productivity, and encouraged the government intervention for improvement (Long, 2010). The working group on fatigue continued during and after the post-war depression as the Industrial Fatigue Research Board, a unit of the Medical Research Council. Eventually the accident studies, and a substantial proportion of the personnel involved, moved into the Industrial Fatigue Research Board (Fingret, 2000).

The two Wars also stimulated rapid development in occupational health and its inclusion in the course syllabus in public health (Schilling & McDonald, 1990). As a result, the first chair in industrial medicine was established in 1920 at St Mary's Hospital, also university departments were founded in Birmingham in 1935, and at Manchester and Durham in 1945 (Long, 2011).

Research on industrial productivity was again high in the agendas of both the government and the industries during the Second World War (Long, 2011; O'Flynn, 1988). The demand for investigating the physiological and psychological factors affecting workers' efficiency at their jobs, and the risks to health associated with particular occupation had increased markedly. The reasons for this interest were to increase the efficiency of the fighting services and factory workers in order to meet the war goals (Medical Research Council, 1949). In 1942, the Association of Industrial Medical Officers suggested to publishing a journal dealing with industrial medicine. Despite the difficulty at that time mainly due to the shortage of papers, the importance of the health of the industrial worker to Britain made the idea easily acceptable ('British Journal of Industrial Medicine', 1968).

Furthermore, several research initiatives, government reviews and policies were developed to tackle OH issues. The following quote from the first report of the Committee on Industrial Productivity, set up by the government in 1947, sums up the importance of this field at that time and shows the collaborative activities established to tackle these issues:

'The importance of increasing productivity is now so generally recognised that much study is being given to it, from different points of view, by various bodies in Government Departments and elsewhere. ... We recognise too, that the subject is continuously studied by all well managed industrial organisations.... We have given particular attention to methods of increasing productivity which do not demand large capital expenditure. ... we have recommended expenditure on some investigations and researches into human factors affecting productivity which, although their full completion will take time, may, we hope, stimulate interest as they proceed and lead to progressive experiments in industrial practice.' (Committee on Industrial Productivity, 1949, p. 9)

Likewise, the MRC, in response to the government interests, established several research centres and programmes in the field of OH including: occupational medicine, occupational physiology, occupational psychology, industrial pulmonary diseases and toxicology. The

work of the MRC in OH during the years 1945-1948 was highlighted as a central area of its research:

'...research into occupational health has shown unprecedented expansion in the last three years, and now represents a very substantial part of the council's programme. Indeed, it may be said that the development of research in this field, and the initiation of research projects into medical and biological aspects of nuclear physics ... have been the two outstanding features of the Council's work in this country since the end of the war' (Medical Research Council, 1949, p.26).

During the interwar period, all research areas related to OH were labelled under the umbrella of OH research. However, by the 1950s, the government support for OH services reduced when efficiency was redefined to mean the least expensive system of production (Long, 2011). This was also influenced by the competition between industrial health services and the NHS for the much needed medical and nursing workforce required in the newly established NHS (Long, 2011). Subsequently, the category of OH research was gradually dismantled. The MRC progressively introduced OH research topics individually (e.g., pneumoconiosis research) or included them under other topics such as Epidemiology. In 1946/7, for example, there were 39 research units/establishments within the MRC remit. From these, there were nine units primarily investigating OH research, and four units partially included, in addition to other areas, OH research (see Table 2-1). However, in 1970/71 the number of units that mainly supported OH research was decreased to four units in addition to another unit that partially supported this field. Nonetheless, there were many established epidemiological units, which potentially supported some OH studies. This example illustrated how the social, economic and political circumstances and the government policies had impacted upon the direction of research in OH and on the development of this field.

Table 2-1: Occupational health research within the MRC during 1947/48 and 1970/71

1947/48		1970/71	
1. Department for Research in Industrial Medicine, London Hospital	Primarily supported OH research	1. Applied Psychology Research Unit, Cambridge University	Primarily supported OH research
2. Industrial Medicine Research Unit, Birmingham Accident Hospital		2. MRC Industrial Injuries and Burn Unit, Birmingham Accident Hospital	
3. Pneumoconiosis Research Unit, Llandough Hospital and other Centres, Cardiff		3. Pneumoconiosis Research Unit, Llandough Hospital	
4. Toxicology Research Unit, Chemical Defence Experimental Establishment (Ministry of Supply), Parton		4. MRC Toxicology Unit, Surrey	
5. Groups for Research in Industrial Physiology at the London School of Hygiene and Tropical Medicine and elsewhere	Primarily supported OH research	5. MRC Unit for the Study of Environmental Factors in Mental and Physical Illness, London School of Economics and Political Science	Possibly supported some OH studies
6. Unit for Research on Climate and Working Efficiency, Department of Human Anatomy, Oxford University		6. MRC Environmental Physiology Unit, LSHTM	
7. Applied Psychology Research Unit, Psychological Laboratory, Cambridge University		7. MRC Environmental Radiation Unit, Leeds University	
8. Group for Research in Industrial Psychology, Manchester, London and elsewhere		8. MRC Epidemiology Unit, Cardiff	
9. Building Research Unit, Birkbeck College, London		9. Epidemiology and Medical Care Unit, Middlesex	
10. Social Medicine Research Unit, Central Middlesex Hospital, London	Partially supported OH research	10. Air Pollution Unit,	Partially support OH research
11. Statistical Research Unit, London School of Hygiene and Tropical Medicine			
12. Wound Infection Research Unit, Birmingham Accident Hospital			
13. Burn Research Unit, Birmingham Accident Hospital			

Source: MRC annual reports of the years 1947/48 and 1970/71

Another example to illustrate the above point is the background and context where the MRC Pneumoconiosis Research Unit (PRU) was established. The PRU was an important OE centre in the UK and its work laid the foundations for medical epidemiology and evidence-based medicine (Cotes, 2000). Due to the many cases of disabling lung disease among the coal miners, a compensation scheme was established in 1929. However, this was available only for the minority of coal miners who worked in hard rock. Later in 1934, the compensation scheme was extended to all underground workers. Nonetheless they had

to comply with the strict definition of classical silicosis and hence the majority of affected workers were not eligible (Tansey, Reynolds, & Ness, 2002). Therefore, both the local doctors and the workers complained about this exclusion. At the same time, the compensation cases granted went up rapidly after the scheme came in, and so did the refusals, and thus there was a great dissatisfaction (Tansey et al., 2002). As a result, the MRC was asked by the Home Office and the Mines Department in 1936 to urgently investigate chronic pulmonary disease among coalminers, particularly the conditions in the south Wales coalfield. The MRC subsequently established the PRU in 1937 and Dr P. D'Arcy Hart was appointed to undertake the medical work, along with Dr E. A. Aslett, and Dr T. H. Belt and Dr A. A. Ferris who did the pathological work (Tansey et al., 2002).

Dr P D'Arcy Hart was interviewed in 2002 to give his account on the historical development of PRU. He explained why the government and the Mines Department (Mines were national wealth and belonged to the government at that time before they were privatised during 1970s) sought to investigate this issues urgently:

'Now looking back, I ask myself why did the Government, which doesn't usually act urgently in this sort of thing, why did they act urgently in this case? I can think of three reasons. One is that the compensation costs were going up rapidly. Secondly, there was a war round the corner and they certainly did not want a dissatisfied coal-producing force. And, thirdly, I like to believe that there was some concern for the health and welfare of the miners' (Tansey et al., 2002, p. 4).

The study team later recommended extending the compensation scheme to cover those who were exposed to the dust, but not necessarily working in the hard rock. Successively, the Workmen's Compensation Act of 1943 took account of the Committee's findings that the key factor was prolonged exposure to airborne dust, particularly quartz mixed with coal and other materials (Tansey et al., 2002).

However, despite the improvement and the research into pneumoconiosis, it was still causing serious problem in the coal-mining industry; where around 5000 new cases were being certified for compensation every year. As a consequence, the National Coal Board (NCB) had started, in 1953, large epidemiological studies throughout the UK to examine the effect of the dust on coal-miners and to obtain accurate data on which to base safe levels of dust concentrations that miners could tolerate without suffering considerable disability (Fay, 1957). The program of research was called Pneumoconiosis Field Research (PFR), which was funded by the National Coal Board and based on the work of PRU. Dr John

Rogan, medical director of NCB directed this research with the agreement of Arthur Homer, who represented the miners (Cotes, 2000). There were 115 full-time researchers and scientists involved in this programme of work, which was funded by the National Coal Board and based on the work of PRU (Fay, 1957). The programme had been successful in establishing compliance limits of coalmine dust levels in both Britain and the US, which have succeeded in dramatically reducing the prevalence of pneumoconiosis in both countries (Attfield & Kuempel, 2003). The programme was subsequently end after about thirty years of work.

In March 1981 a Pneumoconiosis Unit Advisory Committee was established by the MRC to co-ordinate scientific strategy, promote cost effectiveness and review prospects for the future, including the scope for contract work (Cotes, 2000). Subsequently at the end of 1981 Dr Peter Elmes resigned as director followed by retirement or departure of its key staff. The PRU unit was consequently closed down in 1981. However, the main reason for its closing down was that it achieved the goal of eliminating pneumoconiosis and establishing preventative measures. In this regard, Cotes stated (2000, p. 447): *'The epidemiological approach to occupational lung disorders apparently did not have a sufficient market, possibly because it was now part of history. Towards the end, this was also the case of the PRU itself'*

Again, the motive for encouraging OE research in the above examples emanated from social, economic and political concerns. In the above particular cases the concerns are: the cost of compensation, where there was a need to understand the problem so that measures can be taken to reduce pneumoconiosis cases and thus reducing financial and human costs; and efficiency concerns of the workforce during a critical period of the War, where high production of coal was required. However, it is not clear why similar research provisions has not been established since then despite the high rate of work-related illnesses and injuries and the cost impose by these as discussed in chapter one.

2.3.2.1 Data sources

Progress in OH research has also been made through the collection and publication of vital statistics. For example, Guy calculated occupational mortality rates from King's College Hospital's outpatient register and these calculations formed the basis of a series of articles published in the Journal of the Royal Statistical Society from 1845 to 1859 (Morabia, 2013). Additionally, Farr introduced occupation mortality rates in the 25th Decennial Supplement to the Registrar General's report in 1865 (Morabia, 2013). These occupational mortality rates were used to identify hazardous occupations. The relationship between

women's work and infant mortality was one of the indicators of the dangers of industrial labour. The remarkable association between certain occupations and high mortality also revealed the cost to workers' lives (Morabia, 2013). From observations of occupational mortality disparities, doctors could begin to assess the impact of industry on health. The progress of medical understanding of occupational disease highlighted an important consequence of industrialisation that concerned many observers. Hence, as medical understanding of the causes of occupational disease improved, so did the imperative for reform.

Further development in research has occurred through the development of more reliable and complete data sources (Carter, 2000). Reliance on workers' compensation data, in particular for occupational diseases, has been shown to be a poor indicator of the level and impact of such conditions and this has led to the rise of alternative sources of data, such as occupational disease surveillance systems (Sim & Agius, 2009). Key data sources are discussed next.

2.3.2.2 Key data sources

The following are the key sources of information for UK occupational health and safety data:

- **Reporting of Injuries, Diseases and Dangerous Occurrences Regulation (RIDDOR)**

RIDDOR was first imposed in 1980, which was called “the Notification of Accidents and Dangerous Occurrences Regulations 1980 (NADOR)”. It underwent several amendments and the latest was in 2013 as a result of Löfstedt review of the health and safety regulation in the UK to provide clarity for businesses on how to comply with the requirements.

Under RIDDOR employers and the self-employed are legally required to keep a record of certain serious workplace accidents, occupational diseases and specified dangerous occurrences and report these to HSE (HSE, n.d.). The Regulations include lists of the types of dangerous occurrences that are reportable, including those that occur in any situation and those that relate specifically to mines, quarries and railways.

- **Labour Force Survey- LFS**

The Labour Force Survey (LFS) survey is a representative sample of the whole population of the UK households living at private addresses. Its purpose is to provide information on the UK labour market which can then be used to develop labour market policies. The survey is managed by the Office for National Statistics (ONS) in Great Britain and by the Central

Survey Unit of the Department of Finance and Personnel in Northern Ireland ('Labour Force Survey (LFS) - Office for National Statistics', n.d.). The first survey was conducted in 1973 under regulation derived from the Treaty of Rome. Since then it has been expanded, improved and implemented more regularly.

The LFS provides a rich data source of information about individuals' jobs and their personal characteristics, which makes it a valuable source of data for the construction of rates of work related ill-health for relatively detailed categories of workers and jobs; such as injuries, stress, and MSD (Davies, Lloyd-Williams, & Wadsworth, 2013). Nonetheless, it does not cover information on many of the important determinants of work related ill-health.

- **The Health and Occupation Reporting network- THOR**

THOR is a voluntary surveillance scheme for work-related ill health. Under this network specialist doctors agree to systematically report all new cases that they see in their clinics. These reports are collated and analysed by a multidisciplinary team at the Centre for Occupational and Environmental Health (COEH), Manchester University (COEH-University of Manchester, n.d.). The THOR network currently consists of two specialist reporting schemes and one for general practitioners. These are SWORD (based on reports from hospital consultants specialising in respiratory disease) and EPIDERM (based on reports from consultant dermatologists). Another scheme, OPRA (based on reports from occupational physicians), ran until the end of 2010. SOSMI (based on reports from consultant psychiatrists) and MOSS (based on reports from consultant rheumatologists) were effective until the end of 2009.

Several of these databases have been collecting data for over ten years and thus provide a valuable source of data for investigating the risks of particular types of ill health in relation to occupations, industries and causal agents or work activities.

- **Industrial Injuries Disablement Benefit (IIDB)**

Under the Industrial Injuries Disablement Benefit scheme, new cases of ill health, with an established occupational cause, are assessed for disablement benefit (i.e., under prescribed diseases). IIDB statistics are readily available annually from 2003, though earlier historical data are available.

- **Death Certificates**

Some types of occupational lung disease, including asbestos-related diseases, mesothelioma and asbestosis are derived from death certificates. The HSE maintains a register of these conditions, which are supplied to HSE electronically by the Office for National Statistics (ONS) for deaths in England and Wales and the National Records of Scotland (NRS) for Scottish deaths.

2.4 The development of the health and safety regulations at work

The current regulations for health and safety at work originated from the Health and Safety at Work etc. Act 1974. Discussion of how this Act arose and the consequence of its implementation is presented in this section.

2.4.1 The Robens Report

Given the unacceptable level of accidents in the 1960s, a committee was set up, by the Labour government, under the leadership of Lord Robens (Dawson, 1988). The Robens Committee reviewed the existing state of health and safety legislation in Britain. The review was conducted between 1970 and 1972; under a Conservative government. The committee studied various documents and held several discussions with individuals and organisations over a period of two years (Robens, 1972). Additionally, the committee received 183 written submissions from individuals and organisations; held informal talks at various levels, and made on the spot visits (Robens, 1972).

The Robens report revealed that previous inquiries had only tackled segments of the subject of health and safety. Such inquiries included: the 1876 Royal Commission on the Factory and Workshops Acts, the 1938 Royal Commission on Safety in Coalmines, the 1949 Gowers Committee of Enquiry on Health, Welfare and Safety in Non-Industrial Employment, and the 1951 Dale Committee of Enquiry on Industrial Health Services.

The committee concluded that the most fundamental defect of the statutory system was simply that there was too much law:

‘The existence of such a mass of law has an unfortunate and all-pervading psychological effect. People are heavily conditioned to think of safety and health at work as ... a matter of detailed rules imposed by external agencies’ (Robens, 1972, P7).

Further, they strongly concluded that apathy was the main cause of accidents at work:

'..apathy is the single greatest contributing factor to accidents at work. This attitude will not be cured so long as people are encouraged to think that safety and health at work can be ensured by an ever expanding body of legal regulations enforced by an ever increasing army of inspectors' (Robens, 1972, P7).

What was needed to counter this attitude, then, was an *'accumulation of deliberate pressures to stimulate more sustained attention to safety and health at work'* (Robens, 1972, p.151). The report continued,

'There is a lack of balance between the regulatory and voluntary elements of the overall 'system' of provision for safety and health at work. The primary responsibility for doing something about present levels of occupational accidents and diseases lies with those who create the risks and those who work with them ... A more effectively self-regulating system is needed. Reform should be aimed at two fundamental and related objectives. Firstly, the statutory arrangements should be revised and reorganised to increase the efficiency of the state's contribution to safety and health at work. Secondly, the new statutory arrangements should be designed to provide a framework for better self-regulation' (Robens, 1972, p.151-152).

According to the Robens Committee, safety and health at work is an area in which there is a far greater *'identity of interests'* between the *'two sides'* of industry than most other aspects of workplace relations (Robens, 1972, p21); self-regulation is therefore the most effective means of attaining safer and healthier workplaces. Thus, according to the Robens committee, in the context of safety and health, there exists,

'...much scope for constructive discussion, joint inspection, and participation in working out solutions...We have stressed the concept of self-regulation and self-inspection as a basic theme of this report. In this, we do not distinguish between the 'two sides' of industry; if progress is to be made there must be adequate arrangements for both workpeople and management to play their full part' (Robens, 1972, p21).

As well as recognising the importance of external regulators in a system of self-regulation, the Robens Committee also argued that there should be another group of actors which acted both as a contributor to improved safety performance, and as a check against declining standards of performance within any workplace; these were workers themselves. The Robens report thus clearly envisaged workers as having some voice in safety and health issues, and decision making on these:

'...the promotion of safety and health at work ... is not a management prerogative. In this context more than most, real progress is impossible without the full co-operation and commitment of all employees ... We believe that if workpeople are to accept their full share of responsibility (we are not speaking here of legal responsibilities) they must be able to participate fully in the making and the monitoring of arrangements for safety and health at their place of work (Robens, 1972, p18-19).

Thus the Robens committee aimed to develop new *'enforcement tools'* for the inspectorate, namely prohibition and improvement notices, which would allow them to *'exert effective pressure to ensure the prompt rectification of unsatisfactory conditions and circumstances'* (Robens, 1972, p84).

The recommendations of the Robens Committee were implemented essentially in full by the new Labour government of 1974. These recommendations were thus formalised in the Health and Safety at Work etc. Act 1974 (Health and Safety at Work etc. Act 1974). This Act set out a system of self-regulation which established the philosophy underlying safety and health regulation in Britain to the present day. This system of self-regulation focuses, as discussed above, around cooperation between employers, workers and regulators. Deregulation was also seen as an attempt to reduce the state provision of information, education, and enforcement of laws on occupational hazards (Watterson, 1990).

2.4.2 The Health and Safety at Work etc. Act 1974 (HSWA)

The HSWA was introduced on the basis and premises of the Robens report discussed above. It is commonly labelled as an *'enabling Act'*, where it seeks to provide a framework within which earlier health and safety provisions can be revised over time (Hughes & Hughes, 2015). Most significantly, the Act sets out a series of general duties for all those who may be responsible for creating hazards at the workplace, since these are, according to Robens, the people best suited to deal with such hazards. Moreover, given this wider reference to hazards, the Act brought within the scope of health and safety legislation the workers previously uncovered, and the general public, in recognition that industrial activity could endanger the health, safety and welfare of people not employed at a particular location.

The HSWA places on every employer a general duty to ensure, *'so far as is reasonably practicable'*, the health, safety and welfare at work of all his employees. This is a criminal statute originated from the principles of prevention and punishment under which employers are expected to know what their duties are, and how to carry them out. The broad

framework of the statutory provisions of the Act is supplemented by health and safety regulations made as a result of Codes of Practice and proposals issued from the HSE.

The HSWA, then, has been received as a landmark in health and safety legislation. Perhaps its most important distinguishing feature is its attempt to provide a comprehensive coverage. Prior to 1974, health and safety legislation in the UK had advanced piecemeal; as problems became apparent, or as governments could no longer ignore them, regulations were passed to deal with these specific items. The HSWA, then, attempted to provide a comprehensive coverage, and recommend minimum general standards.

It is clear that the main philosophy of adopting a 'self-regulating' system has worked and served many industries, despite its opposition during the early days (Woolf, 1973). The evidence of adopting this approach is consistent with the provisions under the HSWA. For example, Section 2(1) requires employers to take a leading role, to ensure safety, health, and welfare of employees. This was clearly established in the Robens report (paragraph 129). Similarly, Section 3(1) requires employers to ensure the protection of workers not directly employed under them (James, Johnstone, Quinlan, & Walters, 2007).

Hackett (Hughes & Hughes, 2015, p. 5) recently highlighted its benefits and concludes that: *'...the Health and Safety at Work Act has demonstrated it can be applied to new responsibilities and new demands, creating the framework for people to come home safe and well from a day's work in any sector of the economy'*.

Nonetheless, as Dawson (1988, p. 268) concluded *'effective local self regulation of health and safety will not develop and maintained 'naturally' out of the operation of deregulated market forces; elements of government regulation are an essential prerequisites for systems of self regulation at national, industrial and local levels.....the overall performance of the system of local self regulation has deteriorated since 1981 as indicated by published statistic.....this deterioration is marked in specific sectors characterised by small firms, subcontracting, low pay, weak trade unionism and productivity improvements'*.

Besides the HSWA, the European Council Directives also play a significant role in this regard. They are a legal Act of the European Union (EU), particularly aimed at the member states to introduce relevant legislation (Eurogip, 2007). Their aim is thus to ensure a common approach regarding the implementation of various legislation throughout the EU (Eurogip, 2007). As a member state and in compliance with the European Communities Act

of 1972 (*European Communities Act 1972*, 1972), the UK Government introduces secondary legislation, an action known as transposition.

2.4.3 The Health and Safety Executive

The Health and Safety Executive (HSE), was established in 1975 (Lewis, 1975). Prior to its introduction, the Health and Safety Commission (HSC) was established in 1974 alongside the HSWA (HSE, 2013). Its origin is clearly traceable from the recommendation made by the Robens committee as established earlier and Sections 1, 10, and 11 of the HSWA. In 2008, the HSC and HSE merged into a single authoritative body known as the Health and Safety Executive (HSE, 2009).

HSE is a non-departmental public body currently sponsored by the Department for Work and Pensions (DWP) and accountable therefore to the Secretary of State for Work and Pensions (GOV.UK, n.d.). It is led by a non-executive board, which sets the organisation's long-term direction, strategy and objectives. The delivery of these, along with the day-to-day management of HSE is the responsibility of the Chief Executive and the Senior Management Team.

HSE is *'the government body with responsibility for promotion, enforcement, and monitoring of standards of occupational health and safety in the United Kingdom'* (Almond, 2008, p. 109). Whilst other bodies have a role to play in the enforcement of H&S regulations, such as the local authorities, the responsibility of the HSE is one that covers industrial workplaces and hazardous installations (Almond, 2008). Clearly, this illustrates the importance of the role of the HSE as a key enforcement authority. Fundamentally, it is common practice for the HSE to provide advice to employers, oversee strategic H&S decisions and policy creation (Almond, 2008).

The HSE has the responsibility for developing legislation on occupational health and safety, recommendations being submitted to the Secretary of State for Work and Pensions for approval and passage through the Commons and the Lords. As well as drawing up regulations and codes of practice, the HSE is also responsible for research, training and the provision of information regarding health and safety matters; it also has the duty of establishing formal investigations and inquiries into particular incidents.

It is generally stated that the HSE, though officially responsible to the DWP, is in practice largely autonomous (Wilson, 1985); even if this has been the case formerly, the years of the

Thatcher governments saw an explicit impinging upon the autonomy of the HSE. This fact was initially and perhaps most clearly illustrated by Norman Tebbit's, the then Under Secretary of State for Trade, specific instruction to the HSC in 1979 that it take into account economic considerations when developing regulations and recommendations; a request that HSC formally agreed to comply with in 1981 (Wilson, 1985).

2.4.4 Recent developments

2.4.4.1 Dame Carol Black's Review (2008)

The recent economic crisis, coupled with the economic cost of sickness absence and work related disabilities, led the government to review the status of occupational health services in the UK and find ways to meet the needs of business (Black, 2008; Department for Work and Pensions & Department of Health, 2008; Department of Health, 2011; Independent review team led by Dr Steven Boorman, 2009).

The report specified that large companies (those that employ more than 250 people) tend to outsource their OH services to a private provider or to some extent use the NHS OH services (the NHS uses this as a means of income generation) (Snashall & Patel, 2012). Small and medium-sized enterprises (SMEs), which represent a large proportion of UK economy, tend to have limited access to OH services (Department for Work and Pensions & Department of Health, 2008; Snashall & Patel, 2012). To address this issues and as a government response to the Black report, a telephone OH advice service was sat up in 2009 (Sinclair, Martin, & Tyers, 2012).

Another response to the Black report was the introduction of the 'fit note' in 2010, with the aim of reducing sickness absence levels; by encouraging GPs to focus on what a patient can do at work, instead of what they cannot do. Black also recommended a new 'Fit for Work' service that would be extended to those on incapacity or other unemployment benefits. This suggested service would provide support, by adopting a multidisciplinary approach, in relation to financial and housing issues along with NHS services such as physiotherapy and psychological counselling. This service was piloted and currently accepting referrals from employers ('Fit for Work | Free return to work advice and support', n.d.).

Black furthermore argued, in order to make the business case for OH services provision, there is a need for good quality information on activity and outcome to facilitate research and audits that can produce evidence-based practices and knowledge for such provisions (Black, 2008b). Nonetheless, there is evidence that the OH professional and academic base

in UK is declining (Department for Work and Pensions & Department of Health, 2008; Heron, 2015; Williams, Wynn, & Whitaker, 2011). Workforce issues are discussed in section 2.11.

2.4.4.2 Lord Young's Review (2010)

Lord Young was commissioned by the government to review the operation of health and safety laws and the growth of the compensation culture in the UK. *'The aim is to free business from unnecessary burdens and the fear of having to pay out unjustified damages claims and legal fees. Above all it means applying common sense not just to compensation but to everyday decisions once again'* (Young, 2010, p10). The review of health and safety, *'Common Sense, Common Safety'* was published in 2010 (Young, 2010). Young put forward a series of recommendations for improving the perception of health and safety, to ensure it is taken seriously by employers and the general public, while ensuring the burden on small business is as insignificant as possible. The report also demanded restrictions on advertising for 'no win, no fee' compensation claims and a revolution in the way personal injury claims are handled.

The recommendations were welcomed by the government and in 2011 the Government published *'Good Health and Safety, Good for Everyone'*. This policy paper set out proposals to reform the health and safety system in Britain. In particular, addressing the concern of businesses were being burdened by red tape and confusion and that they often felt the need to go beyond the requirements of the law either through extravagant advice from unqualified consultants or for fear of being sued for accidents, even when they were not at fault.

2.4.4.3 Löfstedt's Review (2011)

An independent review of health and safety legislation was undertaken by Professor Ragnar E Löfstedt to evaluate whether changes were required. The focus of his review had been on the 200 regulations and the 53 Approved Codes of Practice maintained by the HSE. In his report *"Reclaiming health and safety for all"*, he concluded that there was no case for radically altering legislation and gave recommendations on changes that would support a more simplified and widely understood approach; and any changes would need to continue to enable businesses to make proportionate decisions about managing workplace risks ultimately reducing incidents and excessive bureaucracy (Löfstedt, 2011).

The HSE has reduced its legislation by 50%, so that there is now a simpler, modern set of legislation. HSE has also redesigned its website to help businesses find straightforward help on what they need to do. Furthermore, the Deregulation Act 2015 was introduced to reduce

the legislative and regulatory burdens affecting businesses, organisations and individuals, as well as put an end to legislation that no longer has practical use. This includes an exemption of about 1.8 million self-employed jobs in occupations that present no potential risk to others from health and safety law.

2.4.4.4 Temple's Review (2014)

The Cabinet Office requires every non-departmental public body to be reviewed by its parent department every three years. An independent triennial review of the HSE was conducted by Martin Temple in 2014, which looked at HSE's functions, form and governance (Temple, 2014). He found the HSE was broadly fit for purpose but recommended an extension of its commercial activities including providing paid-for advice to overseas governments and selling the services of the executive's research arm, the Health and Safety laboratory (HSL) (Temple, 2014). The recommendations of the report were welcomed by the government and the majority were implemented by the HSE (Department for Work and Pensions, 2014).

2.5 Key factors influenced the development of occupational health in the UK

The literature shows that there are chief issues that may have influenced the development of occupational health and medicine in the UK. These issues are discussed next and include: the exclusion of OH from the NHS; issues related to the education of occupational medicine; changes in the higher education research funding system in the UK and specifically research quality assessment; and deindustrialisation.

2.5.1 The Exclusion of occupational health from the NHS

There had been a debate between government departments, industry, trade unions, and health professionals about whether occupational health should be included in the NHS. In early days of this debate, there was general agreement about including OH within the NHS remit (Long, 2011). Early voices, even before the establishment of the NHS, called for nationalised industrial health service: *'We are being driven.... towards a single end. That end is health in industry...operating in the world around us, confronts us with a demand for a sound communal health service'* (Collier, 1936, pp. 214–215).

Collier acknowledged the development, initiated by various parties (e.g. government, employer, research organisations, universities, voluntary initiatives, trade unions), in the field of industrial health services during the past 50 years; though, he advocated the urgent need for coordinating, extension, and simplification of these services:

'At the moment our service is fluid; it can be moulded, modified, extended, and completed. The future of industrial medicine depends on our ability to foresee what order that the real needs of industry may be met by the new industrial health service which we aim at developing' (Collier, 1936, p. 215).

The establishment of the NHS in 1948 marked the start of a period in which the state provided healthcare free at the point of access. Nonetheless, OH was excluded from the NHS remit. The Trades Union Congress (TUC) and the British Medical Association (BMA) both opposed the government proposal of the exclusion of the industrial health services from the NHS. The BMA, in response to the government White Paper "The National Health Service" stated:

'One exclusion which the Government defends in the White Paper is scarcely justifiable -the exclusion of the industrial medical service. This is an employers' service, provided at the employer's expense. As a result, it is common in the bigger and better factories where it is needed more. The factory is an important part of the worker's environment, and the medical supervision of the worker at the factory should therefore be linked with the supervision of his home environment, as part of the same health service. The industrial medical is relatively new, and this linkage should be secured now. The Government's attitude in this is weak and illogical' ('A National Health Service', 1944, p.645).

The government regarded the industrial health services as part of the general welfare services in industry, which primarily were not concerned with the individual medical care, and the workers, as individuals, could still access the NHS for personal healthcare (Department of Health, 1944):

'The present system of factory medical inspection and the arrangements made for the employment by industry of "works doctors" ... are cases in point. From the point of view of industrial organisation, of working conditions in factory, mine and field, there is a continuing and specialised need for enlisting medical skill in ensuring a proper working environment, a proper allocation of types of work to the individual worker's capacity, a proper standard of working hygiene and a general protection of the worker's welfare. The enlistment of medical help for these purposes is part of the complex machinery of industrial organisation and welfare, and it belongs to that sphere more than to the sphere of the personal doctor and the care of personal health- which centres on the individual and his family and his home. What matters is that such specialised services, where they exist, should not impair the unity of personal health service on which he will rely; that, where there arises- perhaps first detected in work place or factory-a question of personal medical

treatment or consultation (beyond recognised incidental services ...) this should be regarded as a matter for the personal health service.’ (Department of Health, 1944, p10).

Another implied reason for the exclusion of industrial health services from the NHS was the existing government Factory Inspectorates and other similar provisions, which perceived to be regulating the workers’ health and safety in industry. Doctors employed in industry, were called “works doctors”. Some large industries voluntarily employed them primarily to support management decisions in relation to health and safety at work, and to provide medical assessment and care for workers especially those employed in high-risk industries. This provision had predominantly been developed during the interwar years to improve the industrial production (Long, 2011). The government encouraged industry to provide such services, which was initially unwelcomed by employers. Notwithstanding, over the years the number of “works doctors” increased in industry largely because of the benefits obtained particularly in reducing absenteeism related to ill-health and accidents (Hansard, 1942).

Long (2011) argues that the establishment of the NHS was a turning point in the way in which OH in the UK was perceived, particularly by the government, as unnecessary when the NHS provided individual health care to all. Subsequently, the NHS competed with the industrial health services for funds and trained professionals (Long, 2011). During the early years of the NHS, the Ministry of Health also complained about the shortage in the NHS workforce and blamed the expansion of the industrial health services for this shortage by competing for the employment of very much needed doctors and nurses (*Report of a Committee of Enquiry on Industrial Health Services*, 1951). Accordingly, in 1949, the government appointed a committee to investigate whether industrial health provisions should be reduced to ensure the survival of the newly established NHS (*Report of a Committee of Enquiry on Industrial Health Services*, 1951). Meanwhile, the government banned any expansion of the industrial health services until the investigation concluded.

The committee found that there were 53,505 medical doctors and 58,892 registered nurses working either full or part time in the NHS, which included GPs, hospital and specialist services, and local authority services. In the industrial health services, there were 3,076 doctors, mostly working part-time and 4,000 nurses. This indicated that approximately 5.4% of the medical workforce and about 6.8% of the nursing workforce in the UK were employed by industry. The committee concluded that the industrial health services are important for industry and complementary to the NHS. It recommended that the

government establish an advisory committee to coordinate developments in industrial health services with a view to expanding provision (e.g., also covering non-industrial areas such as shop and office workers). Other recommendations made by the committee included the need for research to determine the requirements of further health services in industry, further training of medical practitioners in the field of industrial health, further research and the integration and early publication of statistical data collected by various governmental departments. Nonetheless, the recommendations of the committee were ignored by both the Labour and the successive Conservative government. It may be assumed that both were unwilling to commit financial and administrative resources, and because the protection of workers was considered primarily a responsibility of employers (Fingret & Smith, 2013b; McIvor & Johnston, 2013).

As a result, the establishment of OH services in the UK has since been less coordinated and much more limited than most other areas of healthcare (Baxter, 1991). Unlike most EU countries, in which the provision of OH services is generally better than that of the UK with some countries having OH facilities for the majority of the working population (e.g., Belgium, France, Netherlands, and Finland have $\geq 90\%$ coverage) (Faculty of Occupational Medicine, 2006; Valk et al., 2006). Hence, occupational medicine is unlike typical hospital specialties, with the majority of its practitioners working outside the NHS and most of the training posts are outside the NHS (FOM, 2010).

In addition, there are indications that recruitment into training posts in OM is declining (FOM, 2010). One reason for this is an increasing reluctance of OH services in the private sector to take on the costs associated with training specialist occupational physicians; particularly during a recession and with any uncertainty of businesses prospects (FOM, 2010). Furthermore, the experience of medical students of OM in the NHS is rather restricted, in part because it is practiced largely outside the NHS, but also because of confidentiality issues of their patients, many of whom are members of their clinical staff. Consequently, entry to the specialty has tended to occur later in doctors' careers, often following part-time work in OM as a GP (FOM, 2010).

This historical isolation of OM from the NHS has caused uncertainties in relation to its status, validity and future position (Heron, 2015b; 'OM Future', 2015, 'What's in this for Me?', 1976; Raynal, 2015). In addition OM had been without a clear professional academic organisation until the establishment of the Faculty of Occupational Medicine (FOM) in 1978 (Slovak, 2010). The fate of the specialty of OM, its specialist practitioners, and its

academic fundamentals in research and teaching are inextricably linked. With this background in mind, it can be argued that the negative impact of its separation from the NHS, both on the field itself (in terms of academic base, training and research) and on the health of the workforce, is inevitable. These issues were highlighted by the most recent review of OH provision in the UK, conducted by Black (2008):

'Detachment from mainstream healthcare: The historical separation of occupational health from mainstream healthcare has resulted in an inability to provide holistic support to patients of working age..... from its inception in 1948, the NHS only provided occupational health services for its own staff. Providing and funding occupational health for other workers was made the responsibility of their employers. These arrangements might have been right at the time, but it is clear they are failing to meet current needs.' (Black, 2008b, p. 95).

And on the impact of this separation on the field of OM the report stated:

'If we are to fundamentally change the way we support the health of working age people, then we have to address a number of the challenges which face occupational health as it is currently configured. These include the historical detachment from mainstream healthcare, the focus only on those in work, uneven provision, inconsistent quality, a diminishing workforce with a shrinking academic base and a lack of good-quality data.' (Black, 2008b, p. 14).

It is ironic however that since the 1951 Dale Committee of Enquiry on Industrial Health Services, followed by several other reviews, up to the most recent Black review of OH services in the UK, few effective measures have been implemented to improve the OH services in the UK. For instance, the Dale Committee showed that the majority of workforce in the UK had no access to OH services. This state has not improved since then (Black, 2008b; Faculty of Occupational Medicine, 2006; Snashall & Patel, 2012). One cannot help it but wonder, whether the previous and the current UK governments have been genuinely interested in making robust changes.

2.5.1.1 Weakness of the profession

With the establishment of the NHS the medical profession had, according to Leathard (2000), successfully negotiated and achieved most of its objectives including, for example; the option for private practice, the GP independent contractor system etc. Unlike other medical specialties industrial doctors at that time did not have a professional body; they represented only 5.4% of the medical workforce; and worked mostly part time in industry. Thus, industrial medicine perhaps did not have a strong voice, in influencing the

government's decision in regards to the exclusion of industrial health service from the NHS. OM was isolated from mainstream medicine, and was not well regarded during late 1920s and early 1930s. Keeping the link with clinical medicine was therefore perceived necessary to improve the status of industrial doctors. As Lane (1978, p. 115) elucidated, he felt "professionally isolated" when he worked full-time as an industrial doctor:

'...medically, I found myself isolated and lonely. But again, I was lucky in being able to persuade my employers that this professional isolation was neither good for me, nor them, and that I should seek contact with local hospitals and with the Manchester Medical School. Management readily agreed, and I was given a day-and-a-half a week to pursue these contacts. This enabled me to keep my clinical medicine fresh, and secure the interest of the Department of Physiology in some of my new problems... My isolation was relieved.....So, those early days in industry were marked by professional isolation, only overcome by forging what links I could with local medicine. Apart from the Factory Medical Inspectors, there were very few doctors in industry at that time'.

Industrial medicine was also thought to be inferior to clinical medicine. In this regard Lane (1978, p. 118) further attested that: *'The doctors practising industrial medicine— except for the Medical Inspectors of Factories— had not a very good image in the profession. I had long felt that we were in danger of drifting out of the main stream of medicine, and I took every step possible to avoid it. I was very grateful, therefore, when in 1939 I was elected a Fellow of the Royal College of Physicians of London. I felt this was good for the image of industrial medicine. I immediately became a member of the younger Fellows' Club. I have always insisted on retaining this link with clinical medicine and have refused to lose my identity as a physician. I know this stand has been criticized and was particularly so during the war when Public Health sought to take us over'*

The majority of industrial doctors (not the factory doctors) were working on a part-time basis, and at the same time, many of them were working as general practitioners or holding other specialties. The main reasons for these characteristics of industrial doctors could be due to the perceived inferiority and isolation of the field of industrial medicine, coupled with their need for clinical and research links. Nonetheless, the strength of this field later came from these part-time working members, when they were allowed to join the first voluntary Association of Industrial Medicine in the late 1930s (which constitute the majority of the Association).

2.5.2 Education in occupational medicine

Waldron (1974, p. 278) emphasised that in ‘a society which is so heavily industrialised as ours, a case could be made for teaching general medicine as a part of occupational medicine’. More recently though, the GMC’s new “Tomorrow’s Doctors” states that graduates should ‘recognise the role of environmental and occupational hazards in ill-health and discuss ways to mitigate their effects’; ‘Explain sociological factors that contribute to illness, the course of the disease and the success of treatment – including issues relating to ... the links between occupation and health’, and to take care of their own health and consult an OH specialist if needed (General Medical Council, 2009, pp. 16&17). OH teaching can provide an essential educational facet especially when medical students have little understanding or exposure to the working conditions and work demands of their patients (Sokas & Cloeren, 1987). Despite this emphasis on OM, teaching of OH is declining in UK medical schools. Since 1970, several surveys had been conducted to assess the status of OM teaching at UK medical schools (Table 2-2). The authors of these surveys raised concern regarding the evidence of a declining commitment to OM training in the UK.

Table 2-2: Hours given to formal teaching in occupational medicine to medical undergraduates in the UK from 1970 to 2010

Year	Author	Total number of Medical Schools	Number of Schools replied	Number of Schools with formal teaching of OH	Number of Schools with no form of OH teaching	Workplace Visit	Number of Schools have 6 hrs \geq of OH teaching	Number of Schools have \leq 2 hrs of OH teaching
1970	Gauvain,	30	20	20	0	Yes but NK*	6	
1974	Waldron	30	25	15	10	Yes but NK	7	2
1989	Harrington	27	27	20	7	11	7	7
2000	Wynn	24	19	13	6	0	6	7
2010	Williams et al.,	32	21	10	11	0	1	6

*NK= Not Known

The content and duration of OM teaching in undergraduate medical schools varied considerably between medical schools and over the years. The highest known number of hours dedicated for the teaching of OM was 20 hours during the 1960s at Newcastle upon Tyne medical school (Browne, 1969). It has been emphasised that OM should be introduced

early into the medical undergraduate curriculum, to allow students to consider OM as a possible career option ('Undergraduate teaching in occupational medicine', 1978). The competition for teaching time in the crowded curriculum was thought to be one of the main reasons for the insufficient emphasis being given to OH (Schilling, 1991; Snashall, 1989; Williams et al., 2011).

Additionally, OH is often seen as 'soft' subject that individuals can pick up later as and when required (Snashall, 1989). Wynn et al. (2002) suggested to include examination questions on specific aspects of OM to avoid it being perceived as a 'soft' subject by students. Snashall (1989) further maintained that OM is lacking in the curriculum because there are few occupational physicians or academics to argue for its inclusions at the undergraduate level. Wynn et al. (2003) argued that the decline of the academic base in OM in the UK universities (i.e., the decrease in the numbers of academic departments and academics in this field) is one key factor that is contributing to this decline. Other reasons given for this decline include; the continuing focus by medical specialists on traditional occupational diseases such as pneumoconiosis and lead poisoning, and a lack of exposure of undergraduate medical students to OH issues such as workplace visits (Wynn et al., 2003). With the increasing decline in OH medical workforce, the situation is currently worse as shown by the most recent survey of medical undergraduate OH teaching in the UK (Williams et al., 2011). Currently there are fewer schools providing lectures, project work or ward-based education in this subject (Williams et al., 2011).

Waldron (1974, p. 278) complained that *'it is discouraging to find that most of the medical schools in this country take occupational medicine so lightly. In a society where all males spend more than two-thirds of their life in some form of employment and where many women are also in work for long periods, no doctor can afford to neglect the pathogenicity of occupation'*. Given that the lack of undergraduate OM instruction is not a new issue, and, in fact, it has worsened over the years, it is important to update the assessment of the undergraduate OM teaching status within medical schools, and investigate the barriers and potential facilitators of OM inclusion in the medical curriculum.

2.5.2.1 Workplace visits

Workplace visits allow medical undergraduates to understand the work conditions and hazards under which their patients may work, and thus help them to become better equipped to provide the appropriate professional advice (Wynn et al., 2002). Workplace visits, additionally, increase the students' awareness of the influence of the environment on health

and the importance of implementing preventative measures (Schilling, 2013). According to Snashall (1989, p. 434):

“Factory visits” can be impressive- who can ever forget their first descent into a coal mine or view the patent monotony of factory assembly work without being moved? More useful, perhaps, might be a visit to a firefighter's training centre to witness the use of respirators in smoke filled rooms, measure pre- and post-pulse rates, and ponder on fitness to work. This turns a visit into a much more directive educational exercise. If there is no suitable local industry why not use the hospital itself where there are a multitude of industries going on, mostly hidden from view in kitchens, sewing rooms, boiler houses, stores, and incinerators.’

Besides, there is evidence that undergraduate training and workplace visits in OH allow for change in attitudes and improved knowledge in OH, as well as increase medical students interest to peruse OM as a career (Yildiz, Bilir, Camur, & Caman, 2012). Factory or workplace visits formed part of OH teaching in some UK universities, however, these visits were gradually stopped, and currently there is no such visits conducted by any of the undergraduate medical schools. In 1989 about 40% of medical schools in the UK provided workplace visits; whereas since 2000 none has had offered workplace visits (Williams et al., 2011; Wynn et al., 2002).

Several reasons may account for this decline in workplace visits. As industry has been declining, it is becoming unpractical or even impossible to arrange workplace visits (Newson-Smith, 2004). Nonetheless, Waldron (1974) indicated (when industry was at its peak) that these visits were offered primarily as elective subjects and were not well attended, and industry was increasingly reluctant to collaborate for these visits to occur. The experience of medical students of the NHS OH services in teaching hospitals may also be rather restricted due to confidentiality procedures of their patients, many of whom are members of their clinical staff (FOM, 2010). It has been suggested, as alternative when industry workplace visits are not possible, to use medical students’ own working environment (e.g. the wards, laboratories, operating theatres and hospital offices), which may provide a basic understanding of workplace risk assessment and health and safety legislations (Newson-Smith, 2004).

2.5.3 Changes in the UK higher education research funding system

After the Second World War, higher education in the UK was a public service free of charge or at very low cost to students who can demonstrate that they are likely to benefit from it (Brown & Carasso, 2013). However, due to the economic crisis and the government

policies during 1980s about how public services should be provided, higher education model was reshaped from being a public service in the 1980s, to a system dominated by market considerations (Jansen & Pruiskens, 2014). This was initially introduced by the Education Reform Act in 1988, which dictated that universities and colleges were no longer to be state-subsidised services providers, and no longer able to set their own priorities about what to offer students. Instead, they were to be treated as economic organisations selling specific services to the state and to other customers willing to purchase them (Jansen & Pruiskens, 2014). As a result of the Act, a new funding arrangement was established based on the principle of contractual funding where 'higher education institutions were henceforth to be seen as selling teaching (and, in the case of universities only, research) services to the government which was the near monopsonistic purchaser of these services (Jansen & Pruiskens, 2014). This transfer of financial power from the suppliers of academic services to a proxy consumer was extremely far reaching. After this, *'the only way universities could make much effective use of their cloak of legal autonomy was by continuing to diversify their funding sources'* (Williams, 1997, p283).

Thus the 1988 Education Act transformed the universities from being partners of the state in delivering teaching and research, to audited dealers of academic services to the state (Williams, 2004). The Research Assessment Exercise (RAE) (succeeded by the Research Excellence Framework (REF) in 2014), which was introduced in 1986, is the most significant elements of this audit culture within the research function of universities. The criteria for assessing research have gradually moved more towards government control, with the focus on impact. Tapper (2007) argued that the RAE has been used by government to promote an explicit agenda of research specialisation within higher education.

The pressure on the research function of the universities has progressively increased because of a reduction in the university funding, a change in balance between private and public funding sources and research priorities, research audits, and pressure for evidence of research 'impact' and for particular types of research (Tapper, 2007). The emphasis on 'impact' has somehow moved the direction of research away from academic research communities and towards external user communities (Brown & Carasso, 2013). This has reduced the control academics have over the research agenda, with funders and the government increasingly in a strong position to dictate the scope, focus and aims of research (Tapper, 2007). However, this focus has also affected institutional and researchers behaviours, for example some universities merged certain departments to present a stronger

case for research funds (Travis, 2009), and some researchers changed the direction of their work to fit in with the perceived RAE demands (Harley, 2002).

However, this process has not been a simple one of a progressive reduction of higher education autonomy. The RAE has been an area of conflict between government and academia and between competing interests in academia (Tapper, 2007; Travis, 2009). The RAE process in its use of peer-review is thought to be giving preference to pure research over the more applied or user-focused research which has been more crucial to government agendas of exploiting higher education as a resource for the economy, and that this is therefore an area of conflict with government interests which push toward promoting this (Jansen & Pruiskens, 2014). despite increased use of citation based metrics, peer-review rests at the heart of the REF system, and to a certain degree some academics maintain a great deal of influence over how 'good quality' research is defined, though not over the broader audit system (Jansen & Pruiskens, 2014).

2.5.3.1 The rise of Evidence Based Medicine (EBM)

The drive for a user focus has created the possibility of more powerful positions for applied subjects and cross-disciplinary practice-based fields, such as RCTs. The Medical Research Council (MRC) developed the RCT method during the 1940s (the two key trials conducted by the MRC are the use of streptomycin for treating pulmonary tuberculosis, and the use of patulin for treating the common cold) (Johnson, 2013). Since the 1950s, RCTs have progressively become the gold standard research methods in medical sciences (Shorter, 2011). This new method has gradually become popular and supported by the pharmaceutical industries, and thus may have shifted the attention and the prominence from epidemiological studies. This shift has further increased significantly since the establishment of the evidence-based medicine (EBM) by Archie Cochrane in 1970s (Armitage, 2003; Johnson, 2013). One reason that motivated Cochrane to establish the EBM was the motive for a more efficient use of the scarce NHS resources by measuring and confirming whether particular interventions are effective or not. This notion of EBM has been supported by scientific community and policy-makers alike for various reasons but mainly for efficiency and rigor motives, and thus attracted a large amount of funds from various sources (Greenhalgh, Howick, & Maskrey, 2014).

2.5.4 Deindustrialisation

Britain's industrial structure has changed significantly since the 1970s. Production in basic sectors shifted to less-developed countries which offered cheaper production, also more advanced sectors moved to more technologically competitive countries such as Germany

and Japan (Waddington, 2001). The gradual decline in industry and the economic crises that occurred during 1970s and 1980s have had a negative influence on the development of OH services in the UK. OH services were low on the agenda of the government, industry and trade unions during that era because of the recession coupled with the neoliberal policies of the conservative government under Mrs Thatcher. Such policies included the privatisation of the national industries, and the adoption of policies resulted in the weakening the trade unions and labour movement (e.g., the end of “closed-shop” arrangement where union membership was obligatory) (Wrigley, 1997). Trade unions played a key role in the establishment of OH services. When these were weakened, OH services were also adversely affected (Bloor, 2000; Long, 2011).

In response to the economic decline and in order to encourage economic growth and competitiveness, the government pursued neoliberal strategy, deindustrialisation, privatisation, deregulation and decentralisation (Waddington, 2001). The liberalisation and deregulation of capital markets and commercial relations has had a significant impact on traditional manufacturing and industrial enterprises and facilitated the shift towards a post-industrial service society (Waddington, 2001). This has transformed both the forms of employment and the labour market, both of which are liable to affect wellbeing. As a result, huge numbers of jobs were lost in mining and manufacturing industries in the UK. For instance, Coal industry employment declined from 300,000 in the early 1970s to only 14,000 in 2001, and the manufacturing industry employment declined from 8,909,000 in 1964 to 2,515,000 in 2010 (Griffiths & Wall, 2007).

The structural changes in the economy and in modes of production, have also affected a range of political, social, and economic outcomes, including occupational and class structures, welfare states, wage equality, trade union density, education spending and, significantly, health and wellbeing (Collins & McCartney, 2011; Long, 2011; McCartney, Collins, Walsh, & Batty, 2012; Walsh, Bendel, Jones, & Hanlon, 2010). One of the results of this change was the growth in non-employment, causing a significant expanding of geographical and social inequality (Green, 2005). For redundant workers the consequences frequently included long-term unemployment and inactivity, damaging health impacts and, in some cases, increasing problems of substance misuse due to mental health issues as a consequence of losing their jobs (Waddington, 2001). Declining employment has also been accompanied by a sharp rise in the number of recipients of Incapacity Benefit (IB). For instance, IB recipients rose from 700,000 in 1979 to 2.6 million in 1997, and by a further 100,000 after 1997 (DWP, 2005). Although life expectancy has steadily been increasing,

since the 1970s, health inequalities have become progressively prevalent (Marmot, 2001) as a result of these changes.

The service industries, nonetheless, grew rapidly, which accounted for about 78% of workforce (23 million workers) in 2003 (HSE, 2004). For example, banking, finance, insurance, business services and leasing employment grew from 1,442,000 in 1973 to 6,241,000 in 2010 (Griffiths & Wall, 2007). In addition, the number of small and medium sized enterprises (SMEs) has grown dramatically, which in 2003 employed nearly 60% of the workforce. Furthermore, the composition of the workforce has changed; part-time workers constituted a quarter of the workforce in 2003, compared to a sixth in the mid-1970s; half of the employees were women compared to two-fifth; trade union membership has dropped from over 50% of the workers in 1979 to less than 30% (HSE, 2004). There has also been a shift to new patterns and modes of working necessitated by modern economies such as a rise in temporary, agency and contract working, together with an influx of migrant workers both from within and outside the EU. These changes may have reduced work-related health issues resulting from heavy industry; nonetheless, new health issues due to the changes in work modes and patterns has caused other subtle health issues such as stress and musculoskeletal problems.

To reflect the changes in OH issues the 'British Journal of Industrial Medicine' name was changed to Occupational and Environment Medicine in 1994. The changes, according to the editor were because:

'In the early days, the main focus of published papers was on the classic occupational diseases, with investigations of workers exposed to high levels of harmful materials at work. The issues truly were mainly "industrial" and heavy industry at that. More recently, the emphasis has been on the effects of low level exposures investigated either in humans or in animal or cellular models. The occupational health problems of workers in newer industries, such as the electronics industry and the service industries have been addressed. Topics such as the effects of unemployment on health and work related stress are starting to be included. The time is now right for further development of the journal to reflect today's occupational and environmental health problems.' (Cockcroft, 1994, p. 1).

The change from 'industrial' to 'occupational' medicine implied the inclusion of all occupations, not just the traditional heavy industries. The inclusion of the term "Environment" in the title was due to the increasing interest in environmental medicine at that time. *'The nature of environmental health hazards and the methods for investigating their effects are closely allied to the nature and investigation of occupational health hazards. The bodies representing occupational physicians in the United Kingdom are considering including "environmental medicine" in their names or stated aims. It seems*

timely, therefore, to include papers covering environmental issues in a journal for professionals in the occupational health field.'(Cockcroft, 1994, p. 1).

With the decrease in the classical hazardous industries since the 1980s, the delivery of OH has gradually shifted from in-house to contracted-out services (Guidotti, 2013). With the reduction and better control of major classical hazards such as pneumoconiosis and lead poisoning, employers could not see the cost effectiveness of having in-house OH physician and gradually tended to contracted-out OH services (Schilling, 1993). Also, OH services have been primarily provided to satisfy regulatory and legal requirements and thus are largely not comprehensive in nature (Pilkington et al., 2002). For instance, the Department for Work and Pensions (DWP) has increasingly used contracted-out OH services to provide health and disability assessments to inform decisions about benefits or to help people on sick leave back to work (The Committee of Public Accounts, 2016). The DWP also expects to spend £1.6 billion on contracts for around 7 million health and disability assessments from 2015 to 2018. This trend resulted in; reduction of influence of OH professionals within companies, less engagement in the employers' specific needs, and loss of knowledge of the workplace circumstances and environment (Guidotti, 2013). Furthermore, there is evidence that, in-house OH services were able to achieve the highest process quality of care compared to the external OH services (Valk et al., 2006).

2.6 The development of public health field

In several parts of this thesis, issues related to the OH field are compared to the public health (PH) field. Thus, a brief discussion of the development of PH field in the UK is presented in this section. This includes its major development from the nineteenth century until the latest reorganisation in 2013.

2.6.1 The nineteenth century until 1948

The Public Health Act of 1848 gave the right of local authorities to appoint the Medical Officer of Health (MOH) (i.e., a public health doctor), and such appointments were made obligatory in 1872 (Gorsky, 2008). The medical officers of health (MOsH) were assisted by inspectors of nuisances (later known as sanitary inspectors, public health inspectors, and then environmental health practitioners), and Borough Engineers to form the first public health team (Gorsky, 2008; Sheard, 2015).

The MOsH had responsibility for reporting on the health of the area population and the authority to take measures that protected population health rather than an individual's health (Griffiths, Thorpe, & Wright, 2005). The populations and geographical areas of the local

authorities varied considerably and hence the effort of MOsH to their PH duties (Warren, 2000). Until the end of the nineteenth century MOsH were mainly concerned with environmental sanitation, housing, food inspection and control of infectious diseases, including towards the end of the century the administration of isolation hospitals and the clinical care of the patients therein (Holland & Stewart, 1998).

By the interwar period the MOsH managed large departments and had considerable powers over a range of preventive and curative services including health education, maternal and child health school medical services, midwifery, health visiting, social services, and reducing infectious disease, treatment and rehabilitation (Berridge & Stewart, 2012). This era of PH was seen as a 'golden age' especially in relation to their achievement in reducing the infectious diseases (Gorsky, 2008; Holland & Stewart, 1998) and the relatively high investment in PH activities (Levene, Powell, & Stewart, 2004). However, this era was also criticised for: the variations in resources for health between regions and thus the quality of services; poor coordination between public and voluntary agencies; the ignorance of most of the MOsH of the emerging evidence of poor nutrition on ill-health; and the high levels of maternal mortality (Berridge & Stewart, 2012).

2.6.2 During the establishment of the NHS

With the establishment of the NHS, PH was transferred into the NHS as a medical speciality. As a result of this transfer, most PH functions moved into the new NHS and the role of MOH was reduced considerably by removing the provision of hospital and primary care from local government (Griffiths et al., 2005).

The organisation and operation of the NHS was under scrutiny from its implementation and by the 1960s several reviews were undertaken and published, which primarily proposed for all preventive and personal health services to move from local authorities to area health boards (Committee On Local Authority And Allied Personal Social Services, 1968; Ministry of Health, 1968). The Seebohm Report (1968) recommended that all social care staff in local authorities should be brought together in one department of social services which would leave local authority health departments unworkable. Additionally, Seebohm, in response to the demand for leadership and organisation in the promotion of health and in preventive medicine, characterised the MOH as 'the community physician'. The new community physician was to integrate the health services, be a specialist adviser and a skilled epidemiologist (Holland & Stewart, 1998).

2.6.3 The 1974 reorganisation

The 1974 reorganisation of the NHS brought about the inclusion of all subsequently local authority health services into the jurisdiction of the NHS. New area health authorities were established, which would have responsibility for hospital and specialist services, family practitioner services, the personal health services provided by the local health authorities, and school health services (Holland & Stewart, 1998). This was followed by the appointment of community physician and replacing the MOH (Warren, 2000).

Although the new term 'community physician' had been used since 1973, there was little clarity on what that role involved in a new NHS structure that was viewing management as a means of achieving efficiencies (Holland & Stewart, 1998). There was hence a need to provide a systematic training programme for doctors who would have responsibility for the new Health Service. The foundation of a Faculty of Community Medicine (now the Faculty of Public Health since 2003) was hereafter proposed to establish and maintain standards for training and specialist registration and was inaugurated in 1972 (Warren, 2000). The Faculty became part of the Joint Committee on Higher Medical Training and was recognised as the Specialty Advisory Committee on training in community medicine. Membership of the Faculty of community Medicine would become the recognised PH specialist qualification from 1974. The introduction of the specialist training for community medicine supported by the NHS resolved a long-standing obstacle to recruitment to the specialty (Warren, 2000).

The 1974 reorganisation of the health service had also resulted in significant changes to the way in which PH issues were addressed. The problems traditionally associated with poor PH had apparently been eradicated and existing problems were considered to be the result of individual lifestyles and illnesses such as cancer, heart disease and stroke caused by “irresponsible acts” such as smoking, poor nutritional habits and generally unfit lifestyles (Popay & Williams, 2005) .

Furthermore, concerns in relation to health inequalities influenced the direction of PH research and its translation into policy. In 1977, Ennals, then the Labour Government Secretary of State for Social Services, set up an independent inquiry into the issue, chaired by Sir Douglas Black, then Chief Scientist at the Department of Health and Social Security. The Black Report was released in 1980 to the newly established Conservative government (Black, Morris, Smith, & Townsend, 1980). The report showed that lower occupational groups (which represent the less skilled workers with a lower socioeconomic position)

experience poorer health, and that the gap between the lower and higher occupational groups was widening. Thus, the Black Report made a number of recommendations and called for more emphasis to be placed on preventive and primary health care. However, the report was suppressed by the conservative government mainly due to the cost of implementing its recommendations (Berridge & Blume, 2013). Another reason for suppressing this report; considering the unpopularity of the government at that time due to the economic downturn and increasing unemployment, the government might have thought that underlining these issues would have been politically untimely and rather hypocritical (Oliver, 2010). Nonetheless, this report subsequently stimulated media and public interest and a substantial growth in health inequalities research (Oliver, 2010).

Changes to primary care services announced in the white paper Promoting Better Health (1987) gave a clear indication that more attention was to be given to health promotion and ill-health prevention. The traditional influence of secondary and specialist services was being challenged by the purchasing role of health authorities and GPs and consequently, more attention was being given to PH (Ham, 1998). Nonetheless, Ham (2009) argues that a medical model of health with its focus on ill-health was still being given priority, particularly by clinicians. If the problems in relation to health improvement and health inequalities were to be addressed then patients and members of the public had to be central to decision-making about their own lives, the way in which services were organised and managed and the policies that affected health and the wider determinants of health (Bradshaw, 1994).

The Committee of Inquiry into the Future Development of the Public Health Function, chaired by Donald Acheson, was set up after two poorly controlled outbreaks of infection from salmonella food poisoning and legionnaire's disease. The Committee report, Public Health in England (1988), recognised that community medicine had been unable to achieve its functions within the structures that defined it, and the need for a long term view which frequently conflicted with immediate pressures on health authority management. 'Public Health' was reintroduced as the strategic function for the growing prevention agenda and PH medicine as the specialty. The Health of the Nation: a strategy for health in England (DoH, 1992) identified the key areas for preventive action as coronary heart disease and stroke, cancers, mental illness, HIV/AIDS, sexual health, and accidents. However, this White Paper was later criticised for not taking into account the socioeconomic determinants of health, and the strategy and targets were criticised for following mainly a disease-based model (Hunter, Fulop, & Warner, 2000).

2.6.4 During the Labour government since 1997

With the incoming Labour Government in 1997, tackling health inequalities had become a major policy priority. The New NHS White Paper (Department of Health, 1997) gave a clear indication that health improvement was to be prioritised. In addition, the Acheson Report (1988), which was an update of the Black Report (1980), concluded that socioeconomic inequalities in health remained significant and had undeniably become increasingly striking over time, and offered several recommendations that extended far beyond the NHS. As a result, policies such as Our Healthier Nation (Department of Health, 1998) were focused on health improvement and addressing health inequalities and supported the need for the collaboration and partnership working identified in the New NHS White Paper. Our Healthier Nation (Department of Health, 1998), was additionally focused on the premise that it was only people themselves that would achieve health, and the engagement and full participation of communities were essential if health improvement was to become a reality.

The 1999 White Paper Saving Lives: Our Healthier Nation (Department of Health, 1999) set targets for reducing deaths from heart disease, cancer, suicides, and accidents. Health Action Zones were proposed for the most deprived areas in England to facilitate the development of health improvement plans. The NHS Plan (Department of Health, 2000) included a list of actions on health and care. However, a change was signalled by the emphasis on partnership to achieve PH aims, including working with Local Strategic Partnerships and towards the goals of the Neighbourhood Renewal Strategy. Shifting the Balance of Power (Department of Health, 2001b) aimed to make frontline functions the most important delivery vehicles for the NHS Plan which would give primary care trusts (PCTs) major public health responsibilities.

The report of the Chief Medical Officer's Project to Strengthen the Public Health Function in England (Department of Health, 2001a, p. 43) was published and concluded that a "strong, effective, sustainable and multidisciplinary public health function" was needed to deliver on health improvement and reducing health inequalities through addressing the wider determinants of health. The PH workforce was defined as 'strategic' PH specialists, PH practitioners, and the wider PH workforce whose role made a difference to local health and wellbeing. The emphasis on a multidisciplinary workforce was reinforced by the decision that specialists in PH did not need to be medically qualified, could be members of the Faculty of Public Health (FPH) and become Directors of Public Health. Consequently, in 2002, the FPH opened up the Public Health Specialty to non-medical PH professions.

The Derek Wanless report (2002), *Securing Our Future Health*, for the Treasury on what funding the NHS would need long-term, found that the costs of demand for future healthcare would be reduced by good PH prevention policy. The resulting massive increase in NHS spending funded the implementation of the “Choosing Health: making healthier choices easier White Paper” (Department of Health, 2004), but did not make the impact needed to prioritise prevention over healthcare as much of the funding was spent elsewhere (Dowler & Spencer, 2007). Choosing Health restated the individual’s responsibility for their health, focusing on lifestyle issues such as smoking, drinking, healthy diet, exercise and sexual health.

2.6.5 Current developments

Based on the work of Michael Marmot on health inequalities and social determinants of health (Marmot, 2010), the government produced the White Paper “Healthy Lives, Healthy People: Our Strategy for Public Health in England”, as part of the Liberating the NHS reform (Department of Health, 2010). The Health and Social Care Act 2012 followed and included the following reforms:

- clinically led GP commissioning groups with responsibility for the majority of NHS spend;
- an independent NHS Commissioning Board; the abolition of Strategic health authorities (SHAs) and PCTs;
- integration between NHS and local authority services to be promoted through new Health and Wellbeing boards;
- a new body, Public Health England, to lead on public health at the national level;
- local authorities to lead the local public health function;
- the Director of Public Health to be a statutory post;
- the majority of public health staff in the NHS to move into the local authority with some responsibilities moving to Public Health England.

Holland (2015, p. 2) expressed serious concerns in response to the recent relocation of the public health within local authorities (he was involved in the 1974 NHS reorganisation): *‘Life outside the NHS may prove much less attractive for public health practitioners. It is to be noted that neither the CMO (Chief Medical Officer) nor the Chief Executive of Public Health England have any training in public health. The ability to obtain health statistics is likely to be far more difficult. Dealing with outbreaks of disease due to infections, toxicological or other agents may become fraught. The ability of public health to be forthright in the assessment of current practice, situations, conditions or future plans is not*

secure either within LAs or Public Health England'. However, the assessment of the impact of this reorganisation may require a longer period of time to be established.

2.7 Medical workforce in OH compared with those in PH field

There have been ongoing concerns about the decline of OH medical workforce in the UK including those in the academic and research fields (Black, 2008b; FOM, 2010). However, there are no systematically collected data on the size of the OH workforce. The Centre for Workforce Intelligence (CfWI) (The Centre for Workforce Intelligence, 2014) concluded that mapping the current PH workforce in terms of location and number is challenging due to the lack of centralized database for this purpose. Similar conclusion was made in relation to the numbers of OH professionals practising in the UK (CfWI, 2010). Therefore, the CfWI estimated the workforce data from various source, but was not able to provide accurate data for PH in 2014, and provided OH workforce data only within the NHS in their 2010 review.

Thus, obtaining workforce data has also been challenging in this study for both OH and PH fields particularly historical data. Furthermore, the thesis supervisor (DM) and the author approached the FOM to provide any available historical data of the Faculty membership. Their initial response indicated that this might be challenging, but they would do their best to gather the information we need. However, we received no response since despite the several emails to follow this issue up. It is most likely that the information is also not readily available to FOM and they might have not maintained a database that contains this information. However, by searching the literature, reviewing annual reports of the FOM and FPH, and contacting the NHS Workforce team, it was possible to obtain partial data on workforce statistics. OH workforce statistics is compared with those of the PH field when possible.

In both fields, in general there is a decline in the number of specialists from the end of nineteenth century toward the beginning of this century (see Table 2-3). There were about 900 Certifying Surgeon in 1878, whilst 504 OH doctors in 2011, representing 48% decrease. In 1899 there were 1771 MOsH, whilst in 2014 there were 1550 PH specialists, which represent a fall of 12.5%. The number of OH doctors peaked in 1949 with a total of 1841 doctors. This can be explained by the government focus on OH of the workers during the interwar period (Long, 2010).

The PH field was under the remit of local authorities when the NHS was established. This separation also affected negatively the MOsH; their number reduced to just above 900 in 1972. During the preparation for the 1974 reorganisation of the NHS, the Working Party on Medical Administrators, Hunter Report (1972), suggested that the appointments procedures for specialists in community medicine should be as much as possible similar to those for other NHS clinical consultants. The Report recommended that community doctors who complete specialist training should be comparable in terms of status and pay award to the clinical grade of consultant, and they should also be eligible for distinction awards. This report along with the establishment of the Faculty of Community Medicine (FCM) (now FPH), in 1972 improved the status and recruitment of community health doctors (as seen in Table 2-3 for the years 1975-1979) in the NHS ('Faculty of Occupational Medicine', 1978; Warren, 2000).

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Table 2-3: The total number of occupational health physicians compared to public health physicians and the title of these at various time points.

Year	Number of doctors		Title at that period	
	Occupational Health	Public health	OH	PH
1872/8	900	1104	Certifying Surgeon	Medical Officers of Health
~1899		1771		Medical Officers of Health
1943	900		Factory doctors	Medical Officers of Health
1949	1841		Factory doctors	Medical Officers of Health
1962	1561		Factory doctors	Medical Officers of Health
1972	900	900*	Factory doctors	Community Doctor
1975**		693		Community Doctor
1976		738		Community Doctor
1977		738		Community Doctor
1978		734		Community Doctor
1979		732		Community Doctor
2001		~950		
2011	504		Occupational Health consultant	
2013		~1280		
2014		1550 [£]		Public health consultants and registrars (300)

Sources: (Crook, 2016; Gauvain, 2013; LANE, 1978; *Report of a Committee of Enquiry on Industrial Health Services*, 1951; Warren, 2000; Young, 2013, CfWI, 2014)

*Number of applications made to become members of the FCM was 1400, from those 900 were accepted and the rest were still under consideration.

**From 1975-1979- the number of community doctors employed in the NHS.

[£]The average estimate provided by The Centre for Workforce Intelligence (CfWI); including those working in the local authorities, PHE and the NHS.

As illustrated in Table 2-3, the impact of the exclusion of the OH medicine from the remit of the NHS is apparent in the small number of OH doctors employed in the NHS compared to PH doctors. OH doctors who have been working in the NHS represent only a small percentage of those who have been members of the FOM (approximately 7.6 in 1995 and 7.1 in 2014), compared to those working in the NHS from the PH field (the number of those working in the NHS was higher than those who hold the FPH membership). Table 2-5 further shows that the majority of the training posts in OH medicine were largely conducted in the private sector rather than the NHS.

The majority of the FOM members are GPs; according to the CfWI, in 2010, approximately 850 doctors were Associates, Members or Fellows of the FOM practising in the UK, and approximately a further 1100 doctors (mainly GPs) hold the Diploma in Occupational Medicine (CfWI, 2010). This is likely to be applicable in all years and indicates the small number of OH physicians who are directly involved in OH services.

Furthermore, in a workforce planning survey conducted by the FOM in 2011, the number of Members and Fellows of FOM was 687 (FOM, 2010). From those, 457 (66.5%) members were 50 years old or older, which is a clear indication of the aging workforce in this field. This information indicates that the OH workforce is aging, and the lack of newcomers to the field.

In 2013, the number of PH specialist in the NHS decreased by approximately 33.6% compared to 2012 (Table 2-4). The transfer of PH staff to the newly formed department “Public Health England” and the local authorities can explain this fall during the recent reorganisation.

Table 2-4: Total number of the FOM membership from 1995 to 2014, the FPH from 1996 to 2003, and the number of occupational and PH physicians working in the NHS.

Year	No. of PH physicians in the NHS	No of OH physicians in the NHS	FOM members *	FPH members **
1992	3242	74		
1993	3203	75		
1994	2977	87		
1995	2301	99	1300	
1996	2211	93	1313	1421
1997	2155	93	1274	1427
1998	2028	102	1261	1451
1999	1958	106	1453	1496
2000	1863	111	1546	1595
2001	1631	129	1536	1662
2002	1344	137	1602	1808 [§]
2003	1344	137	1649	1990
2004	1394	144	1655	
2005	1331	148	1693	
2006	1268	148	1597	
2007	1456	164	1700	
2008	1421	174	1835	
2009	1559	154	1696	3000
2010	1507	137	1560	
2011	1368	128	1560	
2012	1318	121	1547	
2013	874	108	1532	
2014	742	107	1512	3300
2015	732	106	1515	

*This includes: Affiliating diplomates, Trainees’ Associates, Members, Fellows, Honorary Fellows, Life members, and other specialists

**excluding international and retired members. No data was available within FPH annual reports about membership after 2003.

[§]Since 2002, membership of the FPH has been open to non-medical public health specialists/practitioners

Table 2-5: Number of OH Specialty Registrars (SpRs) in posts

Number of OH SpRs in posts*		
Year	NHS	Private
1999	38	98
2000	41	103
2001	52	106
2002	59	107
2003	61	111

Source: FOM annual reports, 2000-2004.

*No further data were provided in the subsequent FOM annual reports.

2.7.1 Specialty training workforce in occupational medicine (OM)

The FOM has, over the years, been concerned about the difficulty of attracting doctors to join the field of OM (Table 2-6). In 2005, David Snashall in his first year of FOM presidency said: *‘My concern– and it should be yours as well– is that despite the increasing profile of occupational medicine, the numbers entering the specialty remain static. Some of this is due to restrictions on training and some to an improvement in terms and conditions in other branches of medicine, especially general practice from which we have traditionally recruited. It does mean we have to do as much as possible to attract people into the specialty’* (FOM, 2006, p. 6). This concern has persisted as training posts in OM have continued to decrease. The FOM estimated that 37 new specialist trainees are required each year in order to meet the demand for OH consultants (Faculty of Occupational Medicine, 2011). Nevertheless, the same report indicated that the annual intake averaged at 15 trainees. Since the year 2000, an average of 27 FOM Membership per year had been awarded until 2009, whereas 26 specialty trainees were recruited in 2007, 18 in both 2008 and 2009, and 13-14 thereafter (FOM, 2011, 2013, 2015).

In an effort to increase the OM workforce, by increasing the uptake of training posts, FOM has been working with medical schools to promote awareness of OH and interest in OM as a career. The FOM also established a country-wide network of OM leads, and the President at that time wrote a letter, jointly with Dame Carol Black, National Director for Health and Work, to medical schools introducing the network to them (FOM, 2011). The lead’s role is to encourage and help medical schools to include OH in their teaching, and to promote interest in the specialty amongst undergraduates.

Table 2-6: Number of OM trainee in the UK.

Year	No. of OM Trainee
2000	129
2001	139
2002	146
2003	145
2004	142
2005	150
2006	154
2007	NK
2008	NK
2009	115
2010	101
2011	92
2012	79
2013	83
2014	75
2015	74

Source: FOM annual reports, 2000-2015 ('Annual Reports', n.d.).

Yet despite these efforts, OM teaching is still underrepresented and decreasing over the years as revealed by William et al. (2011). Furthermore, there is also a decline in applicants to fill OH specialties posts. For example, in Scotland only, one of three vacant training posts was filled in 2013 (FOM, 2014). This is despite the fact that '*considerable work NHS Education Scotland (NES) is doing at a national level to promote specialty training generally in Scotland, FOM members have been promoting the specialty through participation in undergraduate and postgraduate teaching, incorporating Foundation Year rotations and the development of GP Fellowship posts*' (FOM, 2014, p. 59).

The latest initiative to promote and develop training in OM is the establishment of a new National School of Occupational Health in 2014 in collaboration between FOM and Health Education England. The recruitment of doctors to the specialty of OM has increased since this initiative by attracting 28 trainees in 2014, and 30 in 2015 (Heron, 2015a). However, this number is not yet sufficient to fill up the demand for OH specialists; particularly that the specialty has the highest number of workforce who are above the age of 50 (General Medical Council, 2014) with more than half of its members are over 55 years of age (FOM, 2013).

It is important to consider why the efforts of FOM have not improved recruitment of specialty trainees to OM and what else can be done to attract doctors to consider OM as their future career specialty. However, the influence of these efforts may take more time to be seen; particularly the changes in curriculum, which may require a long period of time to be implemented. On that note, more than 50% of the OH trainees are doctors who are already specialised in other areas (FOM, 2015). It is important to understand why they change their career path to OM. Understanding these issues could potentially help attracting trainees from early stages of their career or to plan their career in this area when they are students.

2.8 Summary

This chapter presented a brief overview of the development of OH services in the UK compared to PH and highlighted the impact of historical events, social, economic and political circumstances on its development.

Prior to the establishment of the NHS, OH of the workforce was a key government priority particularly during the interwar period primarily due to productivity concerns of the workforce. The isolation of the OH from the NHS since its establishment may have had the greatest negative impact on the OH field development. The impact has been on both workers and health professionals. For workers, they had to rely on employers to provide OH, which has not been consistent or available in all industries and workplaces; particularly that of the SMEs. Additionally, except for OH activities that are legal requirements, the available OH services vary from one workplace to another in terms of consistency or comprehension (Sang, Gyi, & Haslam, 2011).

Similarly, PH's golden era was during the interwar period, where it managed a vast majority of healthcare establishments and programmes including public hospitals. Nonetheless, when the PH was incorporated within the NHS, several responsibilities were transferred to the newly established health boards, and PH remained within the local authority remit. PH later gained a better status (in relation to services development, professional status of specialists, research funding, and training opportunities) when the NHS was reorganised in 1974 and PH was transferred to the direct remit of the NHS. Due to public awareness of PH issues; particularly after the Black report, PH received more attention from the government and several government policies helped the field to develop compared to OH field. Nonetheless, OH has continued to be less of a priority despite several policy reviews that recommended significant improvements.

In terms of the impact on health professionals; predominantly physicians, the isolation of OH from the NHS affected negatively the training schemes for those doctors who chose to specialise in OH. Within the NHS, the opportunities for undergraduate and speciality training in OH is limited within the OH departments that are primarily responsible for providing OH services to those who are employed within the NHS. Furthermore, most of the speciality training schemes are available within a limited number of large industries, outside of the NHS; making it difficult for students and trainees alike to see potential career development in this field. Attracting doctors to specialise in this field; thus, has been difficult as shown in section 2.7.1.

The separation of the OH from the NHS, and the diminishing of its workforce, coupled with the decline in industries, the changes in the types and modes of occupations over time, and the changes of workforce demographics, may have had the greatest negative impact on OH field development including research in this area. It can hereafter be argued that OE, being the key research methodology that contributes to building evidence-based information that could ultimately be utilised to introduce improvement of OH of the workforce, may have had suffered significantly due to the above issues. These issues will be the focus of this thesis. Therefore, the next chapter will explore the literature to identify any reported challenges to and facilitators of OE in the UK. This investigation may provide background information specifically for OE field, and may help identify issues and gaps that merit further investigation in addition to the above issues identified in this chapter.

3 THE REPORTED CHALLENGES AND FACILITATORS OF OE RESEARCH IN THE UK

3.1 Introduction

The previous chapter provided a broad and rich background understanding of the development of OH field in the UK and the key issues that occurred during its development. This chapter will specifically examine the literature to identify any reported barriers and facilitators of occupational epidemiology research in the UK and the impact of those issues on research studies. The review aims to answer the following questions:

1. What are the current reported barriers and facilitators of occupational epidemiology research in the UK?
2. What is the impact of these reported barriers/facilitators on research studies?
3. What are the strategies employed by the researchers to overcome challenges?

The review comprises of three stages. The first is a scoping review to identify the existing literature of relevance to this study, to estimate the quantity of research on this area, and to gain an indication of the range of subjects covered in the body of work. The second is a systematic review of studies that were designed to investigate OE research challenges and facilitators. The third stage involved hand-searching of relevant journals for original OE studies, to find out whether the authors of these studies had reported any challenges or facilitators whilst conducting their studies.

3.2 Stage 1: the scoping review

The scoping review entailed a bibliographic database search and the use of a range of keywords (e.g., epidemiology AND challenges AND facilitators) which were then mapped to include all other appropriate thesaurus terms. This search strategy retrieved far too many records covering a wide range of irrelevant topics and it was obvious that the search terms

needed refinement to narrow the focus to challenges and facilitators of OE research in the UK. This exercise also demonstrated that there are very few empirical studies that were carried out specifically to investigate challenges and facilitators of conducting epidemiological studies in general or OE studies in particular. Therefore, at this point, it was decided to include the third part of this phase, namely to assess whether researchers who carried out recent occupational epidemiology research in the UK had reported any issues that either hindered or facilitated their studies as set out in the study reports. This was performed by searching key journals in the field for original articles on occupational epidemiology, and scanning them for any relevant issues noted in the discussion sections of the included papers. The review of papers designed to assess barriers and facilitators, and of researcher’s comments in this area based on empirical research papers.

3.3 Stage 2: Main review search strategy

The search was carried out in the following databases; MEDLINE, Cumulative Index of Nursing and Allied Health Literature (CINAHL), PsycINFO, PsycARTICLES, Cochrane Library, Embase, Web of Knowledge and AMED. Search for grey literature was carried out in Google and Google scholar search engines, Zetoc (MIMAS, n.d.), and Intute databases which remain searchable despite being officially closed in July 2011(‘Intute’, n.d.). Reference lists of included papers were scanned for relevant articles and citation tracking was investigated when practical.

3.3.1 Search terms

Choosing the appropriate search terms was an iterative process, in which various combinations of search terms were applied before utilising the final agreed search terms (Table 3-1). Agreement was reached after consultation with a subject specialist librarian and the supervisory team.

Table 3-1: Search terms operation strategy

Search terms group 1	Epidemiolog* OR “case control” OR cohort OR “cross sectional”
Boolean Operator	AND
Search terms group 2	barrier* OR facilitat* OR challeng* OR obstacle* OR enable* OR incentive* OR Problem* OR difficult* OR hinder* OR hamper* OR imped*
Boolean Operator	AND
Search terms group 3	Occupation* OR industr* OR work OR Labo?r
Boolean Operator	AND
Search terms group 4	UK OR “United Kingdom” OR “U.K.” OR England OR Britain

Although the search strategy in Table 3-1 was the final combination; nonetheless, during the scoping review, different combinations of search terms were used. For example; the search was carried out without the use of search terms group 3, group 4, or both groups 3 and 4. The reason was to identify any studies that reported challenges and facilitators of conducting any type of epidemiological studies and in any country. However, the search result was vast and irrelevant to the study questions; for example, original epidemiological studies investigating epidemiological issues but not challenges or facilitators of this type of studies were obtained.

3.3.2 Criteria for Study Inclusion

The literature was assessed for inclusion based on the following criteria:

- Studies examining barrier(s) and/or facilitator(s) related to occupational epidemiology research in the UK.
- Studies published since 1990 until December 2010 (the search was conducted in mid-2011). As discussed above the current study is focused on current and recent issues that might influence the success or otherwise of OE research and hence older studies are not relevant to the overall question. In addition, the scoping review, which was not limited by time, did not reveal any empirical studies discussing occupational epidemiology research issues prior or after 1990.
- The initial intention was to conduct a systematic review to include good quality studies (assessed by appropriate quality assessment criteria); however due to the limited empirical studies, all relevant quantitative, and qualitative study articles (including reviews) and editorials, commentary and opinion articles were included.

The exclusion criteria were:

- Non- English language studies; it is unlikely that any significant evidence related to UK-based research would be published in a different language.
- Studies addressing the issues related to a country other than the UK.

3.3.3 Data extraction and analysis

Inclusion and exclusion criteria were applied to titles and abstracts, and then to full-text during the literature screening process. The full-text was obtained for those studies that appeared to meet the criteria based on the abstract, or where there was insufficient information to be sure. The inclusion and exclusion criteria were then re-applied to the full-text, and those that did not meet the inclusion criteria, or that met any of the exclusion criteria were excluded from the final review synthesis.

Data were extracted, using a specifically designed data extraction tool. The characteristic of the data included, in the extraction tool, were; the study title, author/s and journal names, study type, methods and population, type of the data collected, any identified challenges or/and facilitators, the stated impact of those on the research study, and the recommendations by the author/s to overcome the challenges.

Thematic analysis was employed to analyse the data extracted from the main review and from the hand search part (Thomas & Harden, 2008). The selected studies were reviewed, and any relevant data that are clearly stated or implied regarding challenges and facilitators were extracted. Important and recurrent themes were identified during the review process, and findings were summarised under thematic headings. Information was then tabulated and colour coded to allow identification of prominent themes and offering structured ways of dealing with the data in each theme. This was iterative process (see Appendix B-1 for an example). Quality appraisal was intended for the main review articles. However, none of these articles met the criteria for inclusion; therefore, quality appraisal was not needed.

3.3.4 The main review search results

The database search strategies yielded 3262 articles. None of them met the inclusion criteria for the review. Three papers (two studies and one opinion piece) were included because they reported on some of the relevant issues for the main study (discussed in section 3.5). The remaining articles were rejected because the vast majority were epidemiological studies focusing on health issues, occupational therapy studies, or not relevant to epidemiology or to challenges and facilitators of conducting research studies. These three studies are analysed and discussed in section 4.3.5, together with those arising from the hand search of journals, the methods and approach for which is described next.

3.4 Stage 3: The review of original OE papers from the hand search of key journals

3.4.1 The Journals search methods

This stage comprises the review of the search for original OE studies published in key journals.

Journal selection

Journals indexed in the Web of Knowledge, whose titles consisted of the terms occupation/al, epidemiology/epidemiologic, and hygiene were included. In addition, the Scandinavian Journal of Work, Environment & Health, and American Journal of Industrial

Medicine were identified, by the field expert supervisor (Prof Damien McElvenny; DMM), to be relevant and were therefore included. Also, another three key journals in the field of public health were included. Thus, the total number of journals being searched was thirty, which are listed in Appendix B-2.

Inclusion and exclusion criteria of the journals articles

The titles and abstracts were screened for the following inclusion criteria:

- Original occupational epidemiology studies reports (refer to OE definition in Chapter 2).
- Study reports of UK-based research. Multi-centre international studies were included if one of the centres is based in the UK.
- Published in the period from 01/01/2010 to 31/12/2010. This year was chosen because the study was focused on the current challenges and facilitators (the study was carried out in mid-2011).

Reports of studies examining issues related to non-occupational epidemiology, and published in non-English language were excluded.

3.4.2 Data extraction and analysis

The process of data extraction and analysis was the same as for the main review, and is given in section 4.3.3.2.

Quality appraisal of the studies located in the journal hand search part was not carried out as the phenomenon of interest was not the findings of the study per se, but the authors' interpretations of barriers to and facilitators of undertaking the study.

3.4.3 Journal search results

Titles and abstracts of all papers published in 2010 and listed in the contents page of thirty key journals were screened. A total of 242 studies were included for further examination, by reviewing the full-text. From those, 208 articles were excluded because they were not carried out in the UK, and one rejected because the study was carried out in several EU countries; it was not clear whether the UK was one of the included sites. The remaining 33 studies met the inclusion criteria, and therefore, were included in the review (Appendix B-3). Thus, the final total number of articles included in the analysis was 36.

3.5 Result from main review and journals contents page reviews

3.5.1 Description of included studies

The three papers included from the main review were a postal survey of 1,000 UK companies, which was carried out to assess the completeness and status of employee biographical and work history records (Rushton & Betts, 2001); a review discussing some of the methodological issues that have affected epidemiological studies on Gulf War veterans (Hotopf & Wessely, 2005); and an opinion article discussing ethical issues and challenges of occupational research (Coggon, 2001b). Due to the small number and the variations between these studies, themes identified within them were incorporated into the journals articles analysis and included in the discussions of other sections in this thesis.

Thirteen out of the 34 journal articles identified in the contents page analysis were secondary studies, utilising data from previous large and well-designed epidemiological studies, such as the Whitehall II study (Marmot & Brunner, 2005). Eight studies were completely dependent on readily available data, which were originally collected for regulatory purposes and from various sources. For example, data about work-related mortality was obtained from The Office for National Statistics (ONS) (Coggon, 2010). In the remaining 13 studies, data was collected directly from the participants themselves using several study designs.

Twenty-seven articles were published in two key journals; 19 in the Occupational Medicine journal, and 8 in the Occupational and Environmental Medicine, whereas, the remaining seven articles were published in six different journals. The target populations were drawn from a range of occupations and varied across the studies. However, office workers, military personnel, and police staff were dominant as target populations, and included within 16 studies.

3.5.2 Study themes

None of the included papers focused on investigating the challenges or/and facilitators of OE research in the UK. Thus, the issues identified either as challenges or facilitators were predominantly implied (particularly in the journal articles) and not directly discussed. They fell within two thematic categories; preparatory phase issues and investigatory phase issues.

3.5.2.1 Preparatory phase issues

None of the papers directly discussed the preparatory work of the study, or provided details of any difficulties or opportunities arose during the actual period planning and setting up the

studies; such as, topic selection, study design, securing funding, and agreements with collaborators. However, some of these issues, and specifically those around planning and deciding on the data sources, and on their availability and accuracy, were indirectly discussed. Obtaining ethical and governance approvals were mentioned in 17 studies, however, no issues were reported regarding whether this was challenging or not.

The included studies utilised data/information and exploited sampling frames from four different sources (Appendix B-3):

1- The main source of data for many of the included studies is from previous well-designed large epidemiological studies. Thirteen of the included studies relied on data from previous cohort or large epidemiological studies; five from Whitehall Study, two from TELIC cohort study (Telic is the code name for UK operations in Iraq), and one from each of the following studies; the PFR cohort (British National Coal Board's Pneumoconiosis Field Research), the Bristol and Cardiff Community Studies, a large epidemiological survey of textile workers, Adult Psychiatric Morbidity Survey (APMS), and Great Britain Asbestos Survey.

These studies included rich data for further analysis as new research questions emerged after the primary analysis of these previous studies, and many of these questions were not anticipated. For example, Virtanen et al. (2010) investigated whether a major organisational change was associated with an increased risk of work disability. The study question was not expected at any prior stages of the Whitehall II cohort, and the baseline data was collected before the organisational change had happened or anticipated to occur, which helped the study to offer firm conclusions:

'Existing work using Screening on recruitment to the Whitehall II study (1985-88) was complete before the gradual implementation of "Next Steps" commenced and thus provided data on health not only before the change itself but also before widespread rumour of change.....this study is unique in terms of its prospective design and the ability to take account of a range of covariates.' (Virtanen et al., 2010, p. 2 and 3).

Another example:

'This study benefits from using data from the Whitehall study, a well-characterised cohort with sufficient power to detect effects within both sexes.' (Elovainio et al., 2010, p. 80).

2- Using sampling frames and utilising secondary data from national data sources ($n = 5$). These sources were designed to collect data routinely for regulatory or statistical purposes. The main sources utilised in the included studies are:

- the Office for National Statistics (ONS):

'Office for National Statistics ... provided us with information on all deaths in men aged 20-74 years in England and Wales during 1979-1980 and 1982-2000' (Coggon, Harris, Brown, Rice, & Palmer, 2010, p. 2).

- biological samples from the UK's Health and Safety Laboratory (HSE):

'Blood samples for lead analysis are sent to HSL from appointed doctors, HSE medical inspectors, occupational health providers and companies for regular biological monitoring for lead exposure.' (Morton, Cotton, Cocker, & Warren, 2010, p. 591).

- THOR network (The Health and Occupation Research network) (Stocks, Turner, et al., 2010; Stocks, McNamee, Carder, & Agius, 2010), and
- death and other registers (Boers, Portengen, Bueno-de-Mesquita, Heederik, & Vermeulen, 2010; Coggon et al., 2010; Roberts, Jaremin, Chalasani, & Rodgers, 2010).

- 3- Using secondary data from records of employees/workers from different companies/organisations ($n = 5$), such as occupational health and human resources records and databases (Roberts et al., 2010; Ryan, 2010). Researchers sometimes decided to include a specific worker population based on their occupational health records completeness and accuracy. For instance; the decision to include London Underground (LU) in CHAP (The Corporate Health and Performance Group) study was because of the comprehensive occupational health system in place; including regular health checks, physical examinations and the availability of accurate sickness absence records:

'LU was chosen for this study as the nature of its work and the comprehensive occupational health system in place meant regular health checks, physical examinations and accurate sickness absence records were available.' (Harvey et al., 2010, p. 363)

- 4- The fourth information source is primary data from the participants themselves ($n = 11$). This was carried out by administering questionnaire, conducting interview and physical examination or screening (Allan, Murphy, & Ayres, 2010; Bevan, Houdmont, & Menear, 2010; Grimsmo-Powney, Harris, Reading, & Coggon, 2010).

3.5.2.2 Investigatory phase: methodological and study design issues

Methodological challenges were encountered due to the unavailability or inaccuracy of the information and data required in order to carrying out the studies. Eight studies excluded some of the study population due to missing or incomplete information about the study population. The main reasons for missing or incomplete data were due to:

- incomplete or inaccurate information collected within the databases/records/registry, such as demographic information, death certificate errors (e.g., (Heraclides & Brunner, 2010). For example Harding and Darnton reported that:

'...the accuracy of the information on death certificates has been the subject of a number of studies. Thus, 91(29%) of the deaths on the Mesothelioma Register were not confirmed by cancer incidence data and may have been misclassified.' (Harding & Darnton, 2010, p. 1079).

- incomplete studies' questionnaires or measurements (e.g., (Gimeno et al., 2010; Virtanen et al., 2010), or external factors, such as loss of historical data that was needed to ascertain current risks. For example during World War II, and industrial action, where in both cases data was missing, inaccurate and less reliable:

'Data for 1981 were omitted because industrial action during that year by Registry Office staff made them less reliable.' (Coggon, 2010, p. 816),

'For the earlier years from 1919 to 1975, details of all suicides were obtained from annual death returns for UK shipping, which, importantly, were based on the same death files at the RSS. However, they did not cover the World War II period from 1939 to 1946 when information on suicides was not produced.' (Roberts et al., 2010, p. 56)

Three studies reported good response rates as a facilitator, which contributed to the statistical power and generalisable conclusions of the studies (Elovainio et al., 2010; Sundin, Fear, et al., 2010; Sundin, Jones, et al., 2010). Another three studies reported low response/participation rate as a weakness, which caused selection bias, and consequently, the studies' findings could not be generalised (e.g., (Heraclides & Brunner, 2010; Olsson et al., 2010).

In addition, some of the data were excluded in the analysis which added to the reduction in the sample size, and caused other issues such as selection bias:

'...all the analyses were conducted using participants with complete data on the measured variables. This meant that more than half the original population was excluded and this is a potential source of selection bias.' (Elovainio et al., 2010, p. 84),

'Participants who did not complete the section on the perceptions of Service were excluded from the analyses (n= 296)' (Sundin, Fear, et al., 2010, p. 654)

3.6 Discussion of both reviews

Some of the studies ($n = 13$, $\mu = 38\%$) utilised data from previous and well-designed epidemiological studies, particularly cohort studies. Researchers might possibly find it easier and more efficient to use these sources because access is less restricted and thus they may not have needed extensive ethical and governance approvals. Because access to the

data had already been granted and the data might have been anonymised. A good example is the Whitehall II study which was a source of data for some key studies included in this review (Elovainio et al., 2010; Heraclides & Brunner, 2010; Virtanen et al., 2010). Over 500 studies have been published from this cohort since its establishment in 1985. The study team have developed a data sharing policy; this includes a data dictionary, which contains the complete list of Whitehall II variables of the data collected that are available for sharing with external researchers. The data sharing policy is conforms to the UK Data Protection Act (1998), and to the funding bodies guidelines; thus the data available for sharing is fully anonymised (<http://www.ucl.ac.uk/whitehallII>), which facilitated the conduct of many epidemiological studies.

An important factor for conducting OE is the existence of occupational records for workers exposed to new or currently unknown hazards; however their existence is entirely dependent upon individual company/employer practices (Betts & Rushton, 1998). Some of the researchers, whose studies were included in the review, had prior knowledge of the data sources they exploited. For example, one of the main reasons that Harvey et al. (2010) decided to choose London's underground rail network workers in their study was because of the comprehensive OH system in place; thus allowing accurate and complete data to be collected. Others, on the other hand, were obliged to make methodological changes due to missing and incomplete data. For instance; Grimsmo-Powney et al. (2010) had to use a convenience sample, which is a less powerful sampling technique than a random sampling, because there was no readily available register that can be exploited as a sampling frame.

Accuracy of information or data may be assessed before, during and after the study being conducted. Assessing the availability and accuracy of information required for the study prior to the study being carried out, can be the best approach (Checkoway et al., 2007). However, it is not always possible to assess the information sources for completeness and accuracy prior to the study due to access restrictions and confidentiality laws (Coggon, 2001a). Researchers are not allowed to access such data sources unless they obtained relevant stakeholders approvals (e.g., management or employer and relevant ethical committee approvals, and governance clearance) and addressed legal requirements regarding data registers and storage; confidentiality of data provided to the study direct by the subject; and access to data held on the study participants by other sources (Coggon, 2001a; Coughlin, 2006). Nonetheless, this might be possible if the researcher has previous access to such sources for reasons other than research (e.g., has access as an employee or occupational physician), or he/she is an expert in the field and aware of the relevant data

sources available that can be exploited. On the other hand, errors and inaccuracy of data sources (e.g., death certificates) are well recognised yet due to the lack of any other data sources, such imperfect sources are regularly utilised.

The designs of OE studies are guided by the study research question and the feasibility constraints (Checkoway et al., 2007). In the studies included in this review, firm conclusions were drawn when the study design was appropriate and the sample size was sufficient to answer the study questions (e.g., (Virtanen et al., 2010)). On the other hand, due to feasibility constraints some of the authors were cautious making firm conclusions. For example Coggon et al. (2010) were obliged to base their calculations on proportional mortality because no satisfactory data were available on the populations at risk in each job group. Thus, risk estimates may have been distorted if there were unusually low or high total death rates in occupations of interest.

In summary, there were no empirical studies found that specifically explored the challenges and facilitators of OE in the UK. Researchers do not tend to discuss the facilitators and the difficulties they have encountered whilst setting up and conducting their studies. This may be because they did not feel strongly about such issues, or, even if they did feel strongly about them, they could not discuss them due to the word limits imposed by many journals, or because such discussions are felt to be inappropriate in primary papers. There was, however, indirect evidence in the included papers that some issues did affect study validity and generalisability (e.g., low response rate, missing data, and data sources). This information occurred mainly in the sections of their papers that discussed the strengths and weaknesses of the studies, and in the method sections.

3.7 Conclusions

The review findings did not provide sufficient information about the challenges and facilitators of OE research in the UK and the impact of those on research studies. Another issue that could not be explored in this review is whether there were any studies that researchers could not complete or commence because of particular difficulties they encountered, and what are these difficulties. Given the lack of empirical studies investigating this issue, including a larger sample of original OE studies from journals contents' search from previous years (beyond 2010), is unlikely to add important findings, and on balance do not merit further allocation of time and resources.

It is also true that this review was somehow resource intensive and the amount of evidence identified remains small and of lower quality, which was not enough to identify relevant key research themes. Additionally, it is limited to the academic OE field and was not broad enough to cover issues related to the general field of OH. Furthermore, its narrow focus on academic literature did not facilitate to identify key policy documentation and other issues of relevance. However, identifying what is known as well as what remains unknown is important for researchers, academics and policymakers. This review has established beyond doubt important knowledge gaps, and the lack of good quality evidence related to the challenges and facilitators of OE field in the UK.

Therefore, these issues merited further investigation and were explored in the subsequent phase of the study by interviewing key researchers in the field and asking them of their perceptions and experiences of these. It was anticipated that key researchers in this field would be able to provide rich data on this topic because of their long personal and research experiences as well as their deep understanding of this field in general. However, before presenting the interview and the subsequent phases of this thesis, the next chapter discusses the overall methodological approach taken in this research.

4 RESEARCH METHODOLOGY

4.1 Introduction

A fundamental step to take when implementing a research project is to consider the epistemological issues that underpin all research and consequently in which paradigm they are situated based upon their worldview (Crotty, 1998). According to (Mertens, 2009, p. 7): *'Researchers' philosophical orientation has implications for every decision made in the research process, including the choice of method.'* Hence, while a researcher can combine quantitative and qualitative data collection methods, he/she tends to align philosophically with one of the accepted research paradigms.

Therefore, this chapter first explores assumptions relating to the ontology, epistemology and methodology of research paradigms in general and how this has informed the design of this research programme. This is followed by a section which discusses the justification and the use of a pragmatic approach and the overall research design chosen for this research, which is a sequential, exploratory, mixed-method study, including the reasoning for choosing this approach. Finally, an explanation of the five phases of the study with the rationale for their use within this mixed-method design is given. Detailed exposition of the specific research methods used in each phase of the study are given in the appropriate chapters (chapters 5, 6, and 7) relating to each phase. The chapter concludes with a consideration of the ethical issues relating to the chosen design.

4.2 Ontological and epistemological considerations

According to Guba & Lincoln (1994, p. 105) a paradigm is defined as: *'a basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways'*. Kuhn (1996) characterised a paradigm as a package of substantive concepts, variables and inquiries attached with methodological approaches and tools. Essentially, a paradigm consists of three basic elements: ontology, epistemology and methodology. For ontology, a researcher defines the

nature of truth and reality. Epistemology raises the question about how investigators come to know that truth or reality. Methodology focuses on the approaches that a researcher should perform to gain knowledge (Guba & Lincoln, 1994).

Different paradigms present different ontological, epistemological and methodological assumptions (Bryman, 2012). The lines of differences between each paradigm have often been a source of debate within the literature. Hence, it is important to carefully examine the characteristics and difference between research paradigms especially in terms of these aspects in order to provide sufficient knowledge to adopt the most suitable paradigm to guide this research.

In the development of social science, depending on the ontological and epistemological assumptions made, approaches taken to studying the social world and its phenomena can be broadly grouped into two key paradigms: objectivism (known as positivism) and constructivism or interpretivism (Bryman, 2012). In terms of objectivism, the ontological position on the social world is that it exists independent of its social actors and their activities (Bryman, 2012). The epistemological consequence of this paradigm is that as this reality is ordered, it can be observed, explained and generalised, to explain other social phenomena. Thus, the task of the social scientist is to develop general theories that explain how the society works (Tashakkori & Teddlie, 2008). Hence, within this approach researchers begin by deducing a theory and then conducting an empirical study to support or refute the theory (Creswell & Clark, 2011; Tashakkori & Teddlie, 2008). This is the approach generally used in natural sciences, and there has been much debate as to whether the methods and techniques of the natural sciences are appropriate to understanding the social world (Williams, 2000).

Research under the objectivist ontology and epistemology has largely been termed 'quantitative' research, although the validity of this terminology has increasingly come into question, as it refers to the techniques and methods that are commonly used, rather than the fundamental methodological approach. Moreover, quantitative research can be purely descriptive or concerned with theory generation rather than testing predictions. Positivists, critical rationalists and realists all share this basic ontology, though they differ slightly in some of its elements.

At the other end of the spectrum lies the constructivist school of thought. Its ontological position views the social world and its reality as being built up from the perceptions and

actions of social actors (Bryman, 2012). It is established on the assumption that individuals, in their process of understanding the world and social life, develop experiences based on subjective meanings towards certain objectives and things (Tashakkori & Teddlie, 2008). Subjective meanings are the product of an embedded mixture of complex and multiple social, historical, and cultural norms and beliefs that are formed through the process of interaction with others (Tashakkori & Teddlie, 2008). Consequently, there cannot be an objective reality existing without the meanings people bring to it, which means there is the possibility of multiple realities, as perceived by different people. Observers construct knowledge through their observations of the world, and create their own meanings of reality, based on their experiences and backgrounds. The way one individual makes meaning about the world would be different from others (Walliman, 2006). The researcher is considered part of the social construction of social life (Creswell & Clark, 2011; Tashakkori & Teddlie, 2008). The role of the researcher in this paradigm is to explore how reality is constructed by different individuals and groups, to start from individual perspectives and to build up patterns and theories (Creswell & Clark, 2011).

This approach follows inductive reasoning, and has largely been referred to as 'qualitative research', but again this is not necessarily appropriate terminology, as it refers more to the methods employed rather than the approaches taken and assumptions made. Additionally, not all qualitative work is based solely on inductive methods. Strauss (1987) highlights how grounded theory not only involves induction but also deduction approach, and he did not consider the grounded theory to be in conflict with positivistic methods in their original work. Hammersley (1996) has also suggested that all research in some way requires a level of induction and deduction. Critical Theory, Structuration Theory, and Feminism are all based on constructivism, but they vary in some of the detailed elements of their ontology.

In conclusion, while there are numerous approaches along a continuum of research paradigms, with various names depending on their ontological and epistemological assumptions, there are fundamentally two views of the world: the objectivist/positivist paradigm and the constructivist/interpretivist paradigm. The prior beliefs of the researcher tend to influence the adoption of a position that leans more towards one paradigm or another. This has epistemological consequences in how social phenomena are explained and predicted.

4.3 Paradigm debate

There has been a debate within the social science regarding the superiority of one or the other of the two major social science paradigms (Bryman, 2012; Creswell & Clark, 2011; Tashakkori & Teddlie, 2008).

Inductive reasoning has been criticised for its lack of depth, and for reduction of the social world to nothing more than people's interpretation (Creswell, 2009). Further, the inductive approach has been criticised for its lack of validity and generalisability (Bryman, 2012), and also for the time and effort spent on gathering data that may not be used to construct a theory (Bryman, 2012; Creswell & Clark, 2011). On the other hand, critics of the deductive approach reject its position on the grounds that they do not believe human behaviour can be '*understood without reference to the meanings and purposes attached by human actors to their activities*' (Guba & Lincoln, 1994, p. 106). It has also been criticised for its misleading findings. If the primary assumption of the theory being tested is wrong, then the findings will have no validity. Further it is criticised for not attempting to explore and introduce innovative knowledge and for focusing only on already existing knowledge. In addition, not all theories are easily tested (Guba & Lincoln, 1994).

Along with the debate about the superiority of one paradigm over the other, there is also the idea of incompatibility. The argument is that quantitative positivist methods are incompatible with qualitative constructivist approaches (Guba & Lincoln, 1994). This idea is based on the traditional assumption, as discussed above, that positivist and constructivist approaches are based on distinctively different epistemological positions and different research cultures (Teddlie & Tashakkori, 2008). This dichotomy between the two paradigms led purist researchers (i.e., researchers who are at the end of each paradigm continuum) to advocate against combining qualitative and quantitative methods in one study (Greene & Caracelli, 1997; Guba & Lincoln, 1994).

4.4 The case for pragmatism

Pragmatist is strongly aligned with the belief system of not being committed to any one ideology or method of data collection but to be guided primarily by the questions at hand and using the most strategic means available to answer them. The pragmatic approach has been defined as: 'a deconstructive paradigm that debunks concepts such as truth and reality and focuses instead on what works as the truth regarding the research questions under investigation. Pragmatism rejects the either/or choices associated with the paradigm wars, advocates the use of mixed methods in research, and acknowledges that the values of the

researcher play a large role in the interpretation of results' (Tashakkori & Teddlie, 2008, p. 713).

Guba & Lincoln (1994) are often referenced as a source of the argument for paradigm incommensurability, but in a more recent article (Guba & Lincoln, 2005), they argue that they have been misunderstood. They say that, although they argued originally that the two paradigms they described are incompatible, they also pointed out that these paradigms and methods are not inherently linked. This separation of methods from paradigms has also been discussed by other researchers (Bryman, 2012; Creswell, 2009), arguing that quantitative methods are not strictly positivist, neither the qualitative methods are necessarily constructivist. Thus, research methods are more independent of epistemological and ontological assumptions than is sometimes supposed (Bryman, 2012; Creswell, 2009).

Additionally, many authors stress that 'there are more overlaps than differences' between both research approaches (Brannen, 2005, p. 175) and propose creative integration between qualitative and quantitative methods (Tashakkori & Teddlie, 2008). Pragmatists hence reject the forced choice between positivism and constructivism but would embrace both (Tashakkori & Teddlie, 2008). Pragmatism also advances multiple pluralistic approaches to knowing, using whatever philosophical and or methodological approach works for the particular research question being studied (Creswell, 2009). Thus, pragmatism avoids the concepts of truth or reality and is a practical and applied philosophy (Teddlie & Tashakkori, 2008) .

Some researchers (e.g., Creswell, 2009; Tashakkori & Teddlie, 2008) argue that the research question should be of primary importance and therefore more important than either the method or the philosophical worldview that underlies it. They have demonstrated that it is possible to combine paradigms by producing successful mixed-methods studies (Creswell, 2009; Creswell & Clark, 2011; Tashakkori & Teddlie, 2008). Pragmatism thus can be seen as a viable alternative to positivistic and constructivist schools of thought, in that it simply uses what works, and can share concerns from positivism as well as from constructivist. There are several advantages to pragmatism including flexibility of techniques, collaborations among researchers from different paradigms, more holistic research, the use of quantitative data to supplement qualitative findings and vice versa, and the ability to combine issues at macro and micro levels (Onwuegbuzie & Leech, 2006).

The methodology that is frequently associated with pragmatism is mixed-methods (Creswell & Clark, 2011). Pragmatists advocate combining quantitative and qualitative data in a single study to make use of the strengths of both methods and to develop a better understanding of the social phenomenon under study. There are scholars who use mixed-methods as a set of research practices that do not necessarily fit with a particular worldview, whether it is positivism, or constructionism (Creswell, 2009). Other scholars argue that researchers can use multiple worldviews, and consider for their research the mixed-methods approach; hence allowing them to use any number of philosophical foundations for its justification and use, but accepting that certain methods are more appropriate under certain circumstances (Creswell, 2009).

4.5 Researcher worldview and the study methodology

For the main target audiences of this study (i.e., epidemiologists and policy makers) larger scale quantitative research has more familiarity, credibility and influence than smaller scale qualitative research. Thus, the theoretical stance of this research tends to be more positivist than interpretivist, and the initial aim was to undertake a quantitative study, using survey methodology. However, as the study progressed, it was realised that research must pay attention to pragmatic, contextual and political considerations, to surface the underlying elements of interest and importance. Although qualitative research is less familiar to epidemiologists and policy makers, the author strongly believes that it would provide valuable, meaningful insights to quantitative data. Additionally, different forms of research and communication are needed to access and facilitate different means of knowing and understanding.

The focus of this study was to explore the challenges to and facilitators of OE research in the UK, to assess their impact on research studies, and to examine what can be learnt about the evolution of research disciplines from studying these. This meant that not only quantifying the issue was important, but also exploring and understanding how and when research areas have started and evolved, and the reasons why this happened. This suggested that simply employing one research approach would not be adequate in order to answer all these questions. By combining qualitative data with quantitative findings, the challenges and facilitators, their impact on OE, and the implication of the findings for other health discipline can be more fully explained. The qualitative and quantitative findings were mutually informative, providing a merged account of what they mean together. This integration offers insights into the concepts and issues that could otherwise not be revealed by the use of one method or approach.

4.6 Overall Research Design- sequential, exploratory, mixed-methods design

There are several factors that need to be considered when developing mixed-methods studies (Creswell, 2009) including: approaches for methods implementation, the level of priority given to either quantitative or qualitative methods, and the purpose and stage of integration. The following sub-sections will draw upon these factors to review the criteria behind the research designs of different mixed-methods studies, and the approach by which they were applied in this study. However, a discussion of the nature of mixed-methods research, and its strengths and weaknesses is presented next.

4.6.1 What is mixed-methods approach?

Mixed-methods research can be defined as '*an intellectual and practical synthesis based on qualitative and quantitative research; it is the third methodological or research paradigm (along with qualitative and quantitative research)*' (Johnson, Onwuegbuzie, & Turner, 2007, p. 129) Thus, it involves the collection or analysis of both quantitative and qualitative data in a single study (Creswell & Clark, 2011).

The approach has been labelled multi-method (also often refers to the use of a combination of methods within a single paradigm) or multigrain, methodological triangulation, integrated or combined, and hybrid. Nonetheless, mixed-methods currently seems to be the preferred term (Bryman, 2012; Creswell & Clark, 2011; Tashakkori & Teddlie, 2008).

The mixed-methods approach contains both strengths and weaknesses. Researchers can use all the different types of data collection available rather than being restricted to the type of data associated with either qualitative or quantitative research exclusively. Furthermore, in a mixed method approach a broader and more complete range of research questions can be managed, and it aids research in answering questions that cannot be answered by qualitative or quantitative approaches alone (Creswell & Clark, 2011) because the researcher is not merely restricted by a single research approach.

This combination allows the strengths of one method to be used to overcome the weaknesses of the other method (Creswell, 2009; Teddlie & Tashakkori, 2008). Insights and understanding of the issues under investigation can then be obtained which might be missed when only a single method is used. Another strength of mixed-method research includes the ability to add quotations and diagrams to attach meaning to numbers, and equally numbers can be used to add precision to words and narrative (Bryman, 2012; Johnson & Onwuegbuzie, 2004). Moreover, mixed-methods enable triangulation to take place. The

triangulation, convergence and corroboration of findings from qualitative and quantitative approaches, can strengthen the conclusions of the study, particularly if they could be shown to provide mutual confirmation (Bryman, 2012) and produce a complete knowledge necessary to inform theory and practice (Johnson & Onwuegbuzie, 2004). This can potentially add insights and better understanding of the findings (Teddlie & Tashakkori, 2008), and could improve both internal and external validity of the research and thus increase the ability to generalise the results compared to a qualitative method alone (Bryman, 2012; Creswell, 2009).

The challenges inherent in this mixed-methods approach were: the need for extensive data collection; greater time scales; analysis of both quantitative and qualitative data and the need to be familiar with both of the traditional perspectives of research methodology. Researchers hence are required to learn about multiple methods in order to logically mix them, justify their use, and be able to use them in a professional manner (Bryman, 2012; Creswell, 2009). According to Leech and Onwuegbuzie (2010), an important issue with mixed-methods is the data validation process, which involves assessing the legitimization of both quantitative and qualitative data. To overcome this issue, researchers need to focus on the data validation of both methodologies separately and to outline the steps taken to address threats to validity (Leech & Onwuegbuzie, 2010). Therefore, in this study, these issues are discussed separately by providing a detailed account (for both quantitative and qualitative methods) of the validity of the instruments employed, their reliability/repeatability, and bias.

While mixing methods does come with risks, it can offer a pragmatic way to answer complex research questions, and potentially an opportunity to develop new knowledge and stretch intellectual debate by its very nature. Nonetheless, based on the arguments outlined previously in this section, it is important that this strategy is justifiable for any piece of research in which it is employed, and that care is taken to sensibly compare/combine the results from each particular method to reinforce the other and alleviate any weaknesses that arise out of such a combination.

A sequential mixed-methods strategy was considered the most appropriate for this study. Given the lack of literature directly related to the topic of study, it was necessary to gain a greater understanding of the challenges and facilitators of OE research in the UK, the perceptions of theses amongst its community members, and to identify themes that could then be quantitatively tested. The literature review alone did not provide enough insight to

conduct a purely quantitative study, and qualitative data alone would not be able to fulfil the research objectives; for example, qualitative data could not quantify the importance of a particular challenge, or its impact on research studies.

Another issue considered when a mixed-methods approach was selected is that the qualitative data can enable the researcher to answer certain research questions, whereas quantitative data are appropriate for answering others. For instance, qualitative research was used to gain better understanding of the key researchers' perceptions of the challenges and facilitators and their impact on OE research in the UK. Given the gap in the literature, a quantitative approach may not be sufficient to provide in depth understanding of these perceptions and experiences. Furthermore, some of the challenges and facilitators may not be obvious to researchers themselves, and they might be context dependent (Bryman, 2012). Qualitative methodology thus offers a flexible approach which could uncover areas that have not been anticipated at the beginning of the research programme, and which could access the range and depth of people's opinions more than a survey approach (Guba & Lincoln, 1994).

4.6.2 How can the methods be implemented?

Researchers have developed various practical approaches to the design of mixed method studies, and to distinguish between a combination of both methods at the level of data collection, as well as at the level of data analysis (Johnson & Onwuegbuzie, 2004; Creswell, 2009). It can be implemented either concurrently or sequentially (Teddlie & Tashakkori, 2008), and this decision usually depends on the specific topic under study.

In sequential mixed-methods research the investigation phases occur in a consecutive order, with one phase emerging from or following the other (Creswell, 2009; Teddlie & Tashakkori, 2008). The research questions to be addressed and the procedures to be used in one phase are determined by the previous phase. Whereas, in concurrent mixed-methods research the investigation phases occur either simultaneously or with some time lapse, in which parts of the same research questions are addressed (Creswell, 2009; Teddlie & Tashakkori, 2008).

This study comprised of four sequential empirical phases (Table 4-1), whereby one method sought to elaborate on or expand on the design and the findings of another method. The research questions were well suited to this design approach. These four phases were used to complement each other, provide additional insights, and built on the data collected

throughout each stage in order to develop a more comprehensive analysis of the primary research question.

Qualitative research addressing the perceptions of OE challenges and facilitators builds on the primary systematic literature review, adding context and filling in gaps, and allowing for the development of a study questionnaire. Quantitative research was then used for the third phase (survey) that was designed to confirm the strength of the findings from the previous phase. The subsequent quantitative phase (i.e., bibliometric analysis) enabled the study to meet the objective aimed at testing the hypothesised relationships among the key constructs identified in the previous two phases. This phase has also provided an additional level of information for analysis and a new hypothesis to be explored in the next qualitative phase. Lastly, the fourth phase returned to a qualitative approach (documentary analysis) to facilitate in-depth exploration of one key issue (i.e., research funding) identified in the previous phases, and to provide essential information to assist in understanding the phenomena under examination.

Table 4-1: Study design and methods of analysis

Study phase	Phase 1	Phase 2	Phase 3	Phase 4
Approach	Qualitative	Quantitative	Quantitative	Qualitative
Data collection method	Interviews	survey	bibliometric analysis	Documentary review
Data analysis methods	Thematic analysis guided by some principles of grounded theory	Statistical and thematic analysis	Statistical analysis	framework analysis
Tools to facilitate analysis	MAXQDA	SPSS and Excel	HistCite and Excel	MAXQDA and Excel

4.6.3 The level of priority given to either quantitative or qualitative methods

Assessing the priority of one method compared to another is an important step in mixed-methods research. Creswell (2009) described the priority given to each approach in the study as the dominant and less dominant features of a study. In other words, deciding which method (quantitative or qualitative) is the dominant over the other, or both should have the same emphasis. It is somewhat more difficult to decide on the priority that should be given to either the quantitative or qualitative research in mixed-methods design. There are several

factors that can motivate the emphasis given. It might be that data collection constraints determine emphasis. For example, quantitative data collected first receive greater emphasis than interview data collected in a second stage. In this research, a priority was given to phase one qualitative study over phase two quantitative study, because phase two was intended to confirm the exploratory phase one study.

Sometimes, the emphasis depends on scholars' genuine interest to understand one group of data more than another. researchers might also be guided by their audience's preferences (Creswell, 2009). Sandelowski (2008) however argues that presenting mixed-methods research for different audiences is a challenge. Nevertheless, qualitative and quantitative methods serve rhetorical purposes, and researchers might strategically focus on one method over the other in order to communicate new knowledge successfully to a particular audience (Sandelowski, 2008).

Overall, the priority or dominance within this PhD study is slightly skewed towards the qualitative method. This is because qualitative approach was more appropriate to answer the research questions formulated or evolved (based on previous phases of this research) in certain phases (the interview and the documentary analysis phases), whilst quantitative approach suited other questions raised or evolved in this research (the survey and the bibliometric analysis phases). Thus, the research questions raised and evolved in this research dictated, in large part, the type of research designs and analyses used (Onwuegbuzie & Leech, 2006). Each phase had a standalone status, except for the survey phase, which acted as a supplementary role to the dominant qualitative interview component.

4.6.4 Purpose and stage of integration

Integration means the synthesis qualitative and quantitative data (Creswell, 2009). Notably though, using qualitative and quantitative methods does not automatically mean that the two types of data and analysis will necessarily come together and be integrated (Sandelowski, 2008). It is also possible that qualitative techniques are used to analyse quantitative data, while quantitative techniques are used to analyse qualitative data (Sandelowski, 2008). Additionally, as the case in this study, conclusions may be drawn from findings across the data sets, but without the need to combine the two methods.

The purposes of using this mixed-methods approach were:

- developmental: whereby one method helps to develop or inform the other (phase one helped the development of phase two, both phases then helped to develop phase three and four, and finally all phases facilitated the development of phase five);
- triangulation: to allow convergence and corroboration of results from different methods. In the data analysis phases mixed-methods was used to triangulate and reinforce findings;
- confirmatory: where one component confirmed some aspects identified in the previous phases (one and two); and
- complementarity: that is, each component would address a different aspect of the study questions (phases three and four).

The purpose of the first phase of this study was to identify themes related to the challenges and facilitators of OE research in the UK, the impact of these and ways to overcome the challenges. The literature review revealed that these issues have never been investigated before. During this phase, qualitative interviews were analysed, then relevant themes identified and explored. A qualitative analysis was employed initially because it best addresses the exploratory nature of the research problem.

Based on the themes identified in the qualitative phase of this research, a questionnaire was developed and administered. The purpose of the quantitative phase was to fully address the themes identified in the previous phase and to enable the development of insights about the same phenomena (issues related to challenges and facilitators of OE research) from different perspectives (i.e., key researchers and the broader community of OE field in the UK).

To elaborate, the survey sought to complement and confirm the initial findings of the interviews, and both methods were used to inform the design of the subsequent phases (i.e., bibliometric analysis and documentary review), thus allowing the refinement and refocusing of the study methods. Those two subsequent phases were employed to investigate and reveal interrelated but different facets of the study phenomena and to add depth and breadth to the study results and interpretations. As a result, combining these methods increased the study validity and confidence in the findings.

Data were gathered from interviews, surveys, and documents (journals articles, funding bodies' annual reports, and other publications). All these data have been analysed separately

and the key findings of each have been brought together to determine the research objectives and draw conclusions.

4.7 Ethical considerations

Permissions to conduct the interview and survey studies were granted by the Ethics Committee of the University of Central Lancashire (UCLan). All data collection and analyses were carried out in accordance with both the 1998 Data Protection Act and using the ethical research guidelines provided by UCLan.

4.7.1 Informed consent

Information sheet and consent form (Appendix A-1 and A-2) were used in the first phase of the study, whilst information sheet (Appendix A-3) alone was used in the survey phase. This is because the questionnaire was anonymous and did not ask for identifiable information. As can be seen from the information sheets, the type of involvement as well as expected time commitments are clearly stated. The consent form emphasised that participation in the study was voluntary and potential respondents were free to withdraw from the investigation at any time.

Participants were required to return the consent forms before the interviews and the data gathering process commenced. The accompanying information letter for the survey questionnaire clarifies that questionnaire completion was voluntary. All information materials provided full contact details of the researcher for further inquiries as well as contact details of the research supervisor, should any issues arise which participants did not wish to discuss with the researcher.

For the last two phases of the study (i.e., bibliometric analysis and documentary review), ethical approval was deemed to be unnecessary, because the data collected are not confidential and readily available in the public domain.

4.7.2 Privacy and confidentiality

Throughout this study, interview and survey participants were only referred to with two-letters identification code and no information was provided which could identify particular respondents. Additionally, careful analyses and presentation of the interviewees' demographic details was removed, because they are key researchers in the field of OE, which is a small community, hence respondents could be easily identified if their demographic details were presented fully. All data were stored in a secure location which was only accessible by the researcher.

4.8 Summary

This chapter described the adopted methodological approach which employed a pragmatic sequential mixed-methods strategy collecting both quantitative and qualitative data through five distinct but interrelated pieces of research: systematic review, interviews, a survey, bibliometric analysis, and documentary review.

The chapter primarily explained the characteristics and philosophical underpinnings of mixed-methods research and justified and illustrated its application in this study, as well as providing an overview of the mixed-methods study design. The final sections outlined strategies adopted to ensure the ethical conduct of this research and provided a brief summary of the chapter.

The next chapter will discuss the results of the first three empirical phases of this study including detailed descriptions of the research strategy, the development of data collection methods and procedures, and the analysis of the data.

5 CHALLENGES TO & FACILITATORS OF OCCUPATIONAL EPIDEMIOLOGY RESEARCH IN THE UK

5.1 Introduction

Chapter two of this thesis showed that several interlinked challenges may have had negatively impacted upon the development of OH field in the UK such as the exclusion from the NHS, the diminishing workforce, and the deindustrialisation. These issues could potentially influence the development of research base in OH, in particular OE; because it represents the main research methodology that produces evidence-based in relation to work-related issues and thus contributes to the improvements of workers' health and the development of the OH field. Nonetheless, these issues have not been fully understood. Furthermore, the systematic review presented in Chapter three indicated that OE challenges and facilitators have not been sufficiently explored empirically. To address these gaps, a comprehensive two-phase study was conducted; a qualitative interview of key OE researchers and a survey of the wider OE research community. In this chapter, each phase is presented and discussed separately. The overall findings are then synthesised and discussed in the last section of the chapter. It is also worth noting that further discussion related to strengths and limitations, implications for practice, and future research, is presented in Chapter 8.

5.2 Aims and objectives

The two phases of the study presented in this chapter were designed to identify and to critically analyse current challenges to and facilitators of occupational epidemiology research in the UK with a view to assessing the impact of these challenges and any strategies employed to overcome the challenges. The specific objectives were to:

- Explore key researchers' perceptions of the current OE research challenges and facilitators, the impact of the challenges, and strategies developed to overcome the challenges.
- Assess whether the issues identified by key researchers and found in the literature are similar or different to those perceived by the wider occupational epidemiology community in the UK.
- Evaluate any other effects of the identified challenges on the participants' research studies.

As demonstrated in Chapter 3, a mixed-methods approach was adopted in this study which combines both quantitative and qualitative methods, to gain a holistic insight (Tashakkori and Teddlie, 2010) into the current OE challenges and facilitators and other related issues. In this part of the study two methods of data collection were used. First, a qualitative method consisting of semi-structured interviews was employed to explore the perceptions and experience of these issues among key researchers. Second, a quantitative survey method was designed to test the emergent themes on the wider community of OE researchers.

Combining mixed-methods in this way does cause a small structural problem in writing this chapter as the pairing of methods and results becomes disrupted by another section. This issue has been addressed by separating out the qualitative and quantitative phases. The two phases are presented in three parts:

Part 1: the qualitative phase, which includes the methods, the results and discussion sections.

Part 2: the quantitative phase, which includes methods, the results, and the discussion sections.

Part 3: the results from the both phases are then synthesised and integrated to address the overall research issues.

5.3 Part 1: Exploration of the perceptions of the challenges and the Facilitators of Occupational Epidemiology Research in the UK

5.3.1 Introduction

This part of the chapter presents the first phase of the study, interviews of key researchers. This includes the methods, results and discussion of the findings.

5.3.2 Method

As shown in the systematic review, there is a lack of literature in this area. This would suggest that there is a lack of data to support the design of quantitative methods at this stage. Qualitative methods are useful in exploring areas where little or no research has been done before (Bowling & Ebrahim, 2005). Likewise, they can produce rich data and thorough understanding of the phenomenon under investigation. The quantitative approach, which is useful when we need to measure the effects of intervention or if we need to quantify people's attitudes, beliefs or opinions toward the topic of interest (Bowling & Ebrahim, 2005), was employed in the next phase of the study for this purpose. Furthermore, due to the originality of the subject being researched, there is little information available in the literature to guide the development of quantitative research tool, and consequently this research may be viewed as being exploratory; again qualitative research is more appropriate in these circumstances, to generate information for subsequent confirmatory research (Bryman, 2012).

Hence, a qualitative research method, in the form of interviews, was used to identify key researchers' perceptions regarding challenges and facilitators. The interviews were guided by some principles of the grounded theory approach (primarily, constant comparison, sample saturation and some aspect of the analysis), which allowed participants to interact and provide their direct opinions and experiences on the issue (Charmaz, 2006; Strauss & Corbin, 1998). Grounded theory is discussed next.

5.3.2.1 Grounded Theory

This phase of the study was about exploring the perceptions of the challenges and facilitators of OE research in the UK. As there was little relevant research work reported in the literature on similar topic with the same context, a grounded theory approach was used for this phase of the study. The Grounded Theory approach was first disseminated by Glaser and Strauss (Glaser & Strauss, 1967) in their research on dying hospital patients. It describes a systematic generation of theory from data that contains both inductive and deductive thinking.

Charmaz (2006) explains that, whereas most qualitative methods allow the researcher to exert some degree of freedom in the analysis stage, grounded theory offers a set of guidelines for a researcher to adhere to in order to increase the validity of the data interpretation. Thus, this qualitative approach is situated nearer to the quantitative approach out of the spectrum of the qualitative data analysis methods. There are different approaches in grounded theory. In order to decide what approach to use for this study, an examination

was made of these approaches. Then the approach adopted in this study is discussed and justified.

A split occurred between Glaser and Strauss, mainly because Glaser (1992) believed that it was not practical to adhere to some of the rigid methodological procedures of coding and developing categories that Strauss was advocating. Strauss rigid roles included:

- The researcher must have no preconceived ideas while collecting and analysing data. This means that a thorough literature review is not advisable before the data collection stage.
- Analysis of the data should start as the data are being collected so that concepts can be identified during the first interview.
- The interview data are coded using a constant comparative method.
- Data are analysed in a specific manner: Codes are grouped together to form concepts. Concepts are clustered together to form categories. Theory then emerges from the categories and concepts. Memos that contain ideas that the researcher has written down during coding also contribute to the emergence of the theory.
- Analysis can only end when theoretical saturation is achieved, in which all of the concepts in the basic theory being developed are well understood and can be verified from the data

Glaser (1992) believed that there should be more emphasis on researchers not being prejudiced when collecting and analysing data rather than not having any preconceptions. Also, Glaser (1992) regarded Strauss and Corbin's (1990) rigid methodological procedures as forcing theory rather than allowing theory to emerge.

Selden (2005) argues that without reviewing the literature prior to embarking on research, as instructed in grounded theory, it is difficult to know whether the study and methodology that the researcher is about to conduct have not been done before. Also, if a researcher were to begin a study with no preconceived ideas, then novice researchers would be better at conducting grounded theory research than those with experience (Selden, 2005). Mansourian (2006) recommends that researchers should not adhere to the rigid step-by-step methodological procedures and view grounded theory as an approach that should fit the context of the research with the researcher justifying each step of the analysis.

Charmaz (2006) developed her version of grounded theory based on the Glaserian and Straussian approaches. Charmaz (2006) also disagrees with the concept of theory emerging

from data and offers the argument that researchers construct theories both by their ideas and experiences and by their interactions with the subjects and their perspectives. She argues for pragmatist underpinnings to her constructivist grounded theory in that the grounded theory methods should simply be viewed as comprising flexible guidelines, rather than methodological rules, and that they can complement other qualitative methods by incorporating specific aspects of the grounded theory approach in other qualitative methods.

Having considered all these positions, the approach taken in this study more closely follows some principles of grounded theory of that of Charmaz (2006). The purpose of this study was not to generate theory, but to understand the phenomenon under investigations (i.e., the perceptions of the challenges and the facilitators). Thus, grounded theory of Charmaz in this context was useful because it is pragmatic, flexible, and provides clear guidelines for the analysis. Additionally, reviewing the literature is crucial in doctorate studies, thus Strauss's approach was not suitable as he recommends against this.

5.3.2.2 Qualitative Sampling

Classically qualitative sampling within a grounded theory approach employs theoretical sampling. This means that the researcher decides who or what to sample next, based on prior data gathered from the same research project in order to make comparisons with previous findings (Glaser & Strauss, 1967). For example, as the case in this study, if one of the interview participants discussed challenges relevant to researchers in another OE sub-disciplines (e.g., cancer), the researcher would then invite another participant from this field to explore the issues in more details. Sometimes, however, qualitative sampling does not follow such a logical plan. Circumstance often provides the researcher with an opportunistic sampling possibility (Patton, 2002). Within the current study, a purposive sampling was used and the majority of key researchers in the field were invited to participate at the same time. They were identified and invited to take part in the study by the field expert supervisor (DMM). This was an important step because he is known to them, and thus his involvement facilitated their response and agreement to participate in the study.

5.3.2.3 In-depth Semi-Structured Interview

Interviews were chosen as the primary method for exploring key researcher's opinions and experiences of the issues under investigation. Semi-structured interviews were conducted, which had a directional framework yet provided flexibility. Some structure was necessary for two reasons. First, semi-structured interviews allowed for some consistency across the interviews. Secondly, the use of an interview guide (with optional prompts and probes), rather than an interview schedule, allowed for greater freedom and flexibility for both

interviewer and respondent. Thus, whilst common topics were covered in all interviews, subjects could be covered in a different order and interviewees had wide discretion to answer questions on their own terms. In the same way, the interviewer could pursue new lines of inquiry that opened up during the course of the interview. Semi-structured interviews simultaneously offer the advantages of breadth and focus.

The initial drafts of the interview guide were developed mainly on the basis of the study research questions. The areas covered in the guide were based on reading of the relevant literature as well as the supervisory team experience, who provided useful comments on how to improve the guide. The aim of the questions was to stimulate discussion particularly on the facilitators and the challenges and the impact of these on OE studies. The pre-planned questions were sufficiently open that subsequent questions could be developed as the interview progressed. These questions were arranged in the interview guide according to their main topics, but the order of the questions in the interviews did not have to follow this model, and primarily based on the participants' answers (Appendix B-4). All interviews were undertaken face-to-face in the interviewee's workplace with the exception of one, which was conducted by telephone.

By the 5th interview, it was noted that enough insights were emerging from interviews to inform the design of next phase survey, which was designed at that time. By the time 7th interviews had been undertaken, the available data were of sufficient breadth and depth to address the study phase objectives. The interviews were undertaken between June-September 2011. Each interview lasted an hour on average, varying between 20 to 70 minutes. Interviews were recorded and transcribed verbatim.

5.3.2.4 Data Organisation and Coding

The aim of coding was to systematically reduce data and identify the emergent themes of the issues associated with the facilitators and challenges of OE research. Another purpose was to design an instrument for the subsequent quantitative phase of the study, and subsequently move into understanding the issues under investigation.

Coding was developed further as the process continued and more data was gathered from the interviews (see Figure 5-1 for a screen shot of the process). Categories were developed as the data and analysis unfolded, which were identified through comparative analysis of the transcribed interviews. Coding continued until saturation of the category (by the fifth interview no new codes or issues appeared in the data) and no new material could be associated with it and other categories were rejected, as they were not saturated. An

example that was excluded is the category ‘carrying out research in other countries’, as it was only raised once.

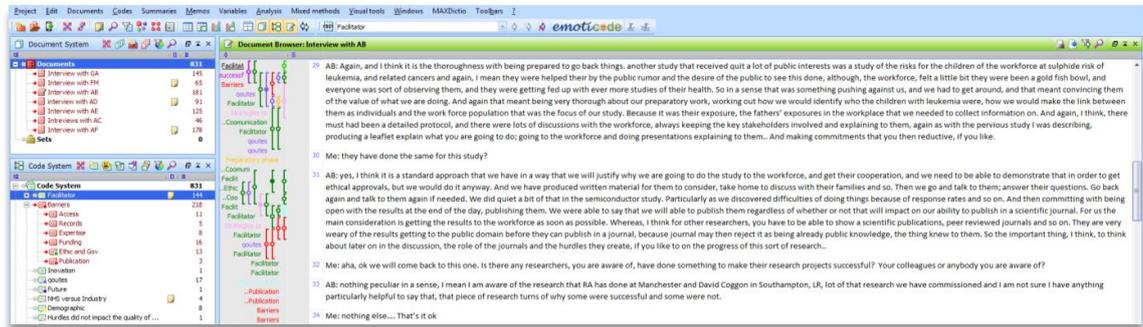


Figure 5-1: A screenshot of coded text in MAXQDA software package.

Each interview was considered to be a data set, and they were compared against each other. Some categories were obvious, take for example comments like *'funding is a problem'*. On the other hand, others provided implicit evidence that the problem requires further understanding and analysis, such as a comment like *'the biggest issue is getting access to populations and that can take years'*.

The whole approach to analysis reflected elements of both deduction and induction because the researcher had a few preliminary ideas about challenges that might influence OE studies (based on the researcher experience and the literature review: ethics and governance approvals challenges, recruitment difficulties and records issues), but the analysis predominantly followed the inductive approach in order to allow new and unexpected findings to emerge. This is commonly the case in grounded theory approaches which tend to entail a constant interplay between induction and deduction (Strauss & Corbin, 1998).

The following summarises the approach taken in the current study based on some of grounded theory guidelines:

- Verbatim transcriptions were made of the recorded interviews.
- Memo writing throughout the process of transcription and interviewing.
- Interviews were examined before the following interview and guided the questions in the second interview.
- Open coding (Strauss & Corbin, 1998) was used, in which transcripts were reviewed manually, line by line, in order to identify patterns or themes and produce key words and phrases (inductive process). This process enabled the researchers to

become immersed in the data and develop early descriptive and brief codes (e.g. Challenges themes, facilitators themes, and impact on the field).

- Patterns within the data were searched through constant comparison and memo writing, based initially on line-by-line reading of the transcribed interviews and re-listening to the tapes to establish initial categories.
- Descriptions by the researchers, identified by actions, ideas or events that shared common characteristics were coded into categories.
- The categories were initially provisional and developed by open coding and further axial coding (Strauss & Corbin, 1998), where systematic linkages between the codes were identified and categories developed.
- Similar factors and variables were identified and given common names, while retaining the unique variables.
- Key themes related to the study's objectives and research questions were identified.
- The identified themes in the transcripts were used to answer the study's research questions.

Computer Assisted Qualitative Data Analysis (CAQDAS) was used to facilitate data organisation, coding and analysis (Coffey & Atkinson, 1996). The transcripts were loaded into MAXQDA software package (MAXQDA 10). This had the advantage of facilitating data display, which has traditionally been a problem in qualitative research (Miles & Huberman, 1984). The steps involved in CAQDAS parallel those used traditionally to analyse text such as notes, documents, or interview transcripts: preparation, coding, analysis, and reporting.

5.3.3 Validity in Qualitative approaches

Guba and Lincoln (1994) argue that a key aspect of good systematic qualitative research is credibility, in that participant experience is accurately interpreted. Silverman (2006) suggests on the other hand that what is required is a form of validity that does justice to, and is respectful of, the participant's experience and contribution to the research. Participant validation, whereby interview scripts and aspects of the analysis are returned to study participants to be verified, modified or rejected, is one technique often used by researchers (Burnard, 1991). However, there are several arguments against this technique which include the additional resources required in order to either reconvene groups or contact individual group members to check transcribed data. An additional argument is that by inviting respondent validation the researcher is asking the respondent to agree with the way in which they perceive they are represented and they may feel uncomfortable in their responses when taken out of context of the original discussion, and may feel that the researcher is inviting

and allowing them to change their response in light of the individual's perception of reality, which is not the case (Bloomer & James, 2003). Bloor (2011) adds that participants' responses given during qualitative interviews may not be consistent across time. Moreover, disagreement may exist between the replies arising in the discussions for respondent checking and the draft of the analysis (Bloor, 2011). Therefore, respondent validation was not applied in this study.

In order to increase the validity of this study, the data generated by the interviews were also checked by an expert member of the supervision (Prof Soo Downe; SD) team in order to ensure there were no discrepancies in the codes generated from the data. Regular meetings with the supervisory team to discuss and scrutinise the data analysis process and presentation was also helpful to maintain rigour throughout the study period.

5.3.4 Reflexivity

Reflexivity is a key aspect in evaluating the rigour of qualitative research. Hardy et al. (2001) state that reflexivity includes reflection on the method of study and the understanding of the research process. *'Reflexivity is not simply a change in research plan as a reaction to poor test results or ambiguous findings; rather, it involves a reflective self-examination of our own ideas and an open discussion and comparison of our research experiences'* (Davies & Dodd, 2002, p. 285).

The way in which a piece of research is developed and undertaken is usually influenced by organisational, professional and personal contexts. Costly et al. (2010) describe the person undertaking research within their own professional setting as an 'insider researcher'. They highlight the potential bias which may be introduced and the need to acknowledge the subjective nature of researching your own practice where there might a risk of lack of impartiality as well as a vested interest in accomplishing certain results. Murray and Lawrence (2000) also highlight the issues of gathering data as an insider and advise the researcher to consider issues of insider bias and validity within their work. There are, however, many positives to researching an area in which you are familiar. Costly et al. (2010) identify how when researchers are insiders they are in a unique position to study a particular phenomenon in depth and with knowledge and shared understanding about particular issues. However, it could be argued that in depth knowledge and familiarity with an area of practice could also lead the researcher to bring with them their inherent bias and lack of objectivity around the issue to be explored in depth.

In this study, being an outsider researcher, I came to research this area with an open eye to any issues that could arise with little preconceived ideas. I was able to recognise issues that

could not be realised or even thought of as a problem to insiders. For example, the OE community was very small, and yet very few members of this field realised this as an issue for the development of this field. Although my knowledge of this field was initially limited, over the study period, I have gradually developed my knowledge and become more familiar with all relevant aspects to this research. This knowledge and familiarity has been built through studying the field's challenges and facilitators, regular meetings and discussions with my supervisory team, and direct interaction with participants and other members through scientific conferences and meetings.

However, it is also worth noting that I came to study this area based on one of my supervisors' experience in this field (DMM). His key issues were in relation to challenges due to ethics and governance clearances and the effect of those on recruitment of research participants, time and cost required to address and comply by these frameworks, and the study validity and generalisability. Furthermore, being a research nurse specialised in the field of cancer, I initially had some vague thoughts of ethics and governance issues in the context of RCTs and other clinical studies. As I became more engaged with this research, I became less convinced that these issues are the main problems in this field, because the frameworks are applicable to most (if not all) health research fields. As research progressed forward, evidence showed that this field's key challenge is the lack of resources, which I explored more in-depth using different methods and perspectives.

5.4 Qualitative Study Results

5.4.1 Participants

A total of seven key researchers participated in this phase of the study. The sample consisted of participants from different research fields within OE (musculoskeletal, respiratory, and cancer). Their experience ranged from 10-30 years. Six of them had medical profession backgrounds and one had a science background. Most of them had a work experience within the NHS, academic, and industrial settings, and one mainly within a governmental body. They carried out studies within a range of settings (e.g., industry, NHS, and private settings).

5.4.2 Qualitative phase results

In order to maintain transparency and clarity, the data collected within the study were conceptually considered in two different levels. Level one is descriptive and relates to the issues reported by the key researchers. This level of analysis was also used for the purpose of developing a survey to test out the emergent themes.

It is important to acknowledge the difference between descriptive data and other type of data which are more interpretive in nature, which requires in-depth analysis to be able to understand the issues under investigation (i.e., not only the challenges and the facilitators, but also their impact, the reason and context of their occurrence). Therefore, in level two data comprised both the interview data, and observations on the researcher interaction and communication with the key researchers during and after the interviews, and was more theoretical in nature.

The role of the researcher within the research process has been considered and it is recognised that the researcher to an extent is inextricably linked to the collection, presentation and interpretation of the data. Attempts have been made to negate any untoward impact of the researcher upon the validity of the findings through the process of in depth discussions with the supervisory team, the use of triangulation and a high level of transparency

5.4.2.1 Level one analysis results

Key researchers identified specific challenges and facilitators of conducting OE research in the UK, the impact of the challenges, and how they overcome some of these. Each of these issues will be discussed separately, though they are in fact interlinked. These challenges occur throughout the various phases of studies. They incorporate lack of funding, difficulties accessing data and participants, lack of expertise, records issues, recruitment difficulties, and publication issues.

Perceived challenges of OE research in the UK

Challenge 1- Lack of funding

'The difficulty therefore, at the end of the day is getting money and it has been difficult to get funding for occupational research' (GC)

Lack of funding bodies that have a specific remit for OE-type research, and thus a paucity of funding opportunities, is the main hurdle perceived by participants:

'There are some charities that fund occupational health research in the UK, but they do not have a lot of money, and not many. There is the Colt Foundation, British Occupational Health Research Foundation. Government funding is considered to be constrained at the moment. It seems that government would have quite early funded (OE research) ...and not being funded now, so that is one big difficulty. And the research council would occasionally fund some work that is relevant to it, but I do not think in general as sees as being very much time in line.' (AC)

Whilst discussing funding difficulties, the participants indirectly stated the types of funding bodies and opportunities for OE research in the UK. Three types of funding sources for OE research were identified:

I. Regular sources of funding for OE research

'At the moment, of course, there is the Colt foundation is a big funder that is from a single family, from a single business and the other is Institute of occupational Health Research Foundation, which it takes its money from different industrial sources. But it is relatively small money' (GA)

The Colt Foundation, an independent charity, was perceived as the primary regular source of funding for OE research. The British Occupational Health Research Foundation was another source of funding noted by the participants, but, due to small amounts of donations (mostly from industry) and the economic crisis, this body was closed down in 2012.

II. Regular and general sources of funding for medical research in general including OE research

The Medical Research Council (MRC), the UK's largest governmental funding body for medical research, occasionally funds specific OE studies relevant to its objectives.

One of the participants (an active environmental epidemiology researcher) thought that the MRC was much better now in terms of funding OE research than 5-10 years ago. It is of interest to note that, during this period, the participant occupied senior positions, in which he might have sought funding from MRC. When asked why he thought funding was getting better now, he replied:

'I think they have got different people, who have got influence within there, but it has just beginning to turn, particularly in the environmental side. And I think the occupational rationale can piggyback on the back of environmental rationale, because the arguments that said earlier are very much the same'. (GA)

The NIHR is another source of national funding body for medical research, yet its public health research programme rarely funds OE research. For example, one particular participant applied for NIHR funding for a very small amount of funding (less than £10,000), and the NIHR offered only half of the amount because the target population was considered to be healthy, and thus, frustratingly for him/her, the study could not be carried out.

Some of the study participants did not regard the MRC and NIHR as being a good source of funding for OE research:

'The funding sources for occupational epidemiology, what are they? Colt foundation, there is the MRC say they would like to [fund OE research], but I have not seen them doing it,

NIHR they again they say they like to do it, but there is no sign of them doing it..... So there are real problems funding wise.’ (AE)

III. Irregular and opportunistic sources of funding for OE studies

a) Industries

Occasionally some big industries will fund particular OE studies. These industries would usually approach the researchers to investigate the health of the workers in their industry if they suspected a problem and are interested in finding a solution to it:

‘I work with some industries now, that X industry, the Y industry, Z industry, and they all active in sponsoring further work in their industries.’ (AD)

‘There are plenty of examples of projects where, particularly in bigger industries, will pay, we are being paid by the S industry to look at the health of workers exposed to C (hazardous substance).’ (GA)

The motivation for industry to fund such studies is either a genuine interest in investigating the health problem of their workers, or an attempt to try to demonstrate (to the public or regulatory bodies) that they are actually dealing with a health problem, particularly if the study is not costly to set up:

‘If they realised there has been in theory a problem or potential health risk, and if you set up a surveillance scheme, then a) you are actually doing something, and b) you are being seen to be doing something. And it has not cost them very much.’ (GA)

‘They (a particular industry) came to us saying they had a problem, and they wanted our help in sorting it out. So the motive, primary motive was theirs, which meant that, obviously there was a quiet a bit of enthusiasm from their end.’ (AE)

On the other hand, not all industries are interested in finding out that there is a potential health risks in their industry due to legal and compensation issues (e.g. fear of litigation or regulatory action):

‘The other sort of issue you have to be careful about or aware of is the legal and insurance issues. So when it became clear that this was a really big problem for this company. Then they began to get nervous, and their insurers get nervous, and the lawyers get nervous, and all sorts of thing. So that makes life a little trickier.’ (AE)

One participant was not able to convince a specific industry with a potential health risk and said: *‘they do not want to know if there is a problem and they certainly they do not want to know how big it is. (AE)*

b) Health and Safety Executive (HSE)

HSE is another governmental funding source, but it is not a regular source for external research. It primarily commissions research that is directly related to its regulatory needs and to the need to reinforce policies in relation to health and safety at work. Three

participants mentioned that HSE have their own funding schemes, in which it funds the Health and Safety Laboratory (a HSE agency) to carry out these studies, and currently, again due to financial difficulties, it rarely funds external research:

'The HSE do not have a lot of money to fund external research, and they have been the HSE laboratory, which used to be an agency to HSE, [then] moved to new buildings, that were put up with private financial initiative, so there was a big debt associated with them. A lot of interest has to be paid. As a consequence, there is a pressure on HSE to commission its research to HSL (Health and Safety Laboratory) rather than to go to outside groups like universities and things.' (AF)

One of the researcher thought it was unfair that HSE cut their external funds to mainly fund their own internal research, which in fact, according to the participant, can be carried out better by academics who have more skills and experience:

'they (HSE) will only commission work which is directly relevant to their regulatory needs, so that being able to reinforce policy and things like that, which is very worthy research, but it is deadly dull, and really it does not leave the door open. They have their own internal funding stream, which they fund their HSL and that is uneven playing field, because they in fact doing research which others outside feel they could have done a lot better, because we (academics) have better skills. And so it is a bone of contention at the moment.' (GA)

Challenge 2- Difficulty accessing data and participants

In order to gain access to the study data and participants, researchers have to seek approval from different stakeholders depending on the type and setting of the study. To access participants and data from the NHS, ethical and governance approvals are generally required. If the study is conducted in a specific industry, the approval of the industry management or the employer is primarily required. Ethical and governance approval in this case is also required. Additionally, the researcher's institution would normally review the study proposal for ethical and governance approvals. Therefore, several and multiple levels of clearances are usually required.

Overall, the study participants agreed that there were access difficulties. Notwithstanding, the focus of their discussion was primarily dependant on the settings and types of the studies that they had conducted. Those who required access to participants and data from industry emphasized the challenges of gaining employer or industry management agreement. However, those who required accessing data and participants from the NHS focused on NHS ethics and governance approvals difficulties. Some, who conducted both types of studies, mentioned both industry and NHS approvals challenges.

Obtaining approval from industry management or employers was perceived to be more challenging. This was because the decision of whether to agree on carrying out a study, is made by the management or employer, and if the manager/employer objects, (mainly

because of fear of finding a health problem, and then possible litigation) then the study cannot be conducted, or in some cases it may take the researchers a very long time to persuade them that the study is worth doing. Three of the participants provided examples of studies that they could not conduct due to industry management or employer refusal:

'two biggish issues are getting access to populations and that can take years.....Two main difficulties we have one is getting buy in from industry, so at the moment I am very interested in working in the X industry, because there is a big problem with Y (health condition) there. But trying to persuade the industry that this is something needs to be looked at is very difficult, and they are not at all enthusiastic. (AE)

The second common issue with access is gaining ethical and governance approvals. This process was described as onerous, tough and takes a very long time:

'It was a very onerous process (gaining ethics and governance approvals) to go through, to get all that. And nowadays of course, it is much more onerous, and the driving force is the autonomy of the individual subject, and a belief that only with the consent of an individual one can have access to their data, which is a big challenge.' (AB)

Some of the researchers complained about the complexity, length and inappropriately designed forms required to be completed in order to obtain ethics and governance approvals (discussion about the forms are mainly designed particularly for interventional studies e.g., RCTs):

'We have had in the order of more than 15 different online forms to be filled in. The online forms are inappropriate; for example, they ask you what age your subjects will be, they do not say whether they mean the age when they were recruited to the study, the age now; many of them are dead, and some of them would be 130 by now if they were still alive. But if you do not fill something in the box, the form will not let you proceed to the next element. So lots of time wasted filling forms that are not properly designed, that have to be done online.' (AF)

There was a contrary view however among two participants who emphasised that obtaining ethical and governance approvals was not a major challenge for them. They thought this issue is a minor problem compared to funding issues and getting approval from industry. However, both participants agreed on the complexity of the process and the forms required to be completed in order to successfully obtain the approvals. For example, one of the participants clearly stated that:

'Ethical issues have not been a major problem, and of course they are important. But most ethics committees seem to accept that these studies are important, and as long as you safeguard confidentiality, then no it is not been a major issue, I mean filling out ethics forms is a right pain and in the gain through the bureaucracy of setting up a study is painful, but that is a minor problem compared to the ones I have talked about earlier.' (AE)

These two participants are academics who conducted their studies predominantly within industry, and thus they often do not need NHS ethics and governance approvals. The main issue in term of access in their case is the industry management approval of the study;

without this, they would not be able to set up or conduct their studies. For instance, the second participant response, when asked about ethics and governance issues, clearly clarified his studies were mainly conducted in industry settings and thus ethics and governance is less of a problem as these are reviewed by the researcher's institution:

' I do not see that as a particular problem. You know there are, the ethics, the only thing about ethics is of course, the NHS ethics system will not do ethical review of worker populations, but then that is alright, our University has established an ethics committee to deal with that. I have not got that. The research governance, you have to follow the rules of research governance of the institution.' (GA)

Also, both participants believed that going through ethics and governance procedures is not specific to OE research:

'Ethics forms I find are poor, because they are tedious and complex and long winded and they are overcautious in my view, but that is a generic thing that is not specific to occupational research.'(AB)

Challenge 3- Lack of expertise

Lack of expertise in certain areas of OE is another difficulty that some researchers are experiencing. Certain skills and experience are required for a study to be appropriately designed and conducted:

'In this country there are very few academics, certainly in x (a specific disease area) occupational epidemiology. So there is a very small community, and that means it is probably below a critical point or so. So if for example, you want to find someone with an expertise in academic occupational hygiene, very hard really. There are very few of them left in this country. So gaining good opinions on exposure measurements is pretty tricky.' (AE)

Difficulties exist in getting expert opinions, because OE researchers are few in the UK, as mentioned by the above participant, and they are getting older according to another participant. Additionally, universities are not sufficiently investing in OE field, which is usually a peripheral subject incorporated within the dominant environmental department/group, and hence few novice researchers are coming to this field:

'The cohort of occupational researchers in the UK are rather old, like me, and there is not a clear career structure for younger folk who want to come in to occupational research lines. Only one lecturer in occupational research in all over the UK. There is one or two in sort of peripherals areas which do something in work and health, but the difficulty is the lack of career structure.' (GA)

The lack of career structure of younger researchers is due to the fewer training programmes available in the UK universities or research institutions and consequently the lack of future professional and career development opportunities:

'I think because of Universities are not invested in this particular area of research, they are increasingly becoming more interested in environmental science, and very often, as with our department and to that extent in Y and Z departments (in two different universities), you have occupational and environmental together. It is a bit easier to get folks who want to do environmental research but not so for occupational research. And this goes back to 30-40 years, no 30 years maybe, when the London School of Hygiene closed down its very good department of occupational research, and it sent out a very bad message to other universities. So they are now in terms of true multidisciplinary departments of occupational research, there is A and Z (two universities' departments) and that is it.' (GA)

Another reason for the lack of career structure for young researchers and lack of university investment in this area is that this field is perceived as being an old fashioned:

'They (UK universities) did not train them (occupational hygienists) anymore. I did not know where they all gone. The ones I have worked with most recently, have been all trained in the Netherlands. It is not just a fashionable field in this country.' (AE)

Challenge 4- Records issues

The accuracy, completeness, accessibility and availability of the working population records are other hurdles discussed by the participants:

'There are gaps in records, there always are. Looking retrospectively at somebody else's data has been collected for other reasons other than you research, there is always a problem.' (FM)

These issues varied from one workplace to another, ranging from minor information missing, or *inappropriate storage of records*, to unavailability of records due to early destruction:

'there are problems sometimes (related to records), and it depends upon the employers, and the employees to those being released..... we know that occupation is very poorly recorded in primary care notes. I think that is an issue, which needs to be addressed.' (AE)

The early destruction of the records is considered a major issue in comparison to other problems such as the accuracy or missing information within the records. According to two participants, who experienced this hurdle, it was not possible to carry out some studies due to the unavailability of the workers records:

'Sometimes there are technical reasons why one might not go ahead with research that it would be valuable to do, and this is due to local factors such as the failure to retain the appropriate records.' (AB)

'You will have so many industries, where they have thrown away their records of people left more than 10 years ago. So you cannot study any of them there.' (AD)

Most participants, on the other hand, seemed to expect these kinds of hurdles, and believed that records issues (except for missing records) are minor technical problems that are always experienced in OE studies. Researchers therefore are able to deal with these issues

somehow. Furthermore, there is a consensus among the participants that occupational health is commonly poorly recorded particularly in General Practitioners (GPs) and hospitals records. For example, this participant was referring to missing information in such records as technical issue that can be dealt with:

'That is very variable (records issues); sometimes they are a complete mess. But I do not see that as a problem, I see that as a technical thing you have to overcome. I do not see that as a barrier, it is just part of the game really in occupational epidemiology is to try and get the exposure assessments, and health records, but is not, and obviously you would like everyone to have, you know, perfect individual exposure measurements, and perfect individual health records, but it is not the case. So I did not see that as a major barrier, that is just a technical thing you have to overcome.' (AE)

Challenge 5- Recruitment difficulties

The core *issue* discussed, by all participants, in relation to recruitment was the low response rate to population surveys, which was reported to have been getting lower over time:

'Also we have problems with lower response rates now than we used to get, and this has been a trend over time..... historically, I have done studies where I had response rates of 80%and now you might get 50% or something like that. It is very much poorer than it used to be, the response rate.' (AF)

Another issue that could make it difficult to carry out OE studies was reported to be legal and compensation issues that might affect staff involvement in the study, and researchers need to be aware of these issues. For example, one of the participants had to abandon a study because the study participants were not cooperative and honest:

'We had started the study, we had a lot of cooperation from both management and trades unions, we had put a lot of preparation in to get everybody on board. It was not the people were refusing to take part; they just were not being honest. And it became clear that the study was not going to provide useful information, so we had to abandon it. the workforce consistently was lying about their symptoms, because they thought it might affect their eligibility for compensation.' (AF)

Challenge 6- Publication issues

Publishing research findings is another challenge, albeit it was considered the least troublesome. The main concern was the difficulty in publishing OE studies in high quality journals, particularly if results are disseminated to the workforce at first, meaning that the findings were in the public domain. According to some of the participants, another reason for publication bias (lack of acceptance of OE papers) was due to the lack of use of new cutting edge methodologies and techniques in OE studies, which meant that journal editors did not see the findings as exciting or innovative. Additionally, journals specialising in publishing OE studies typically have low impact factors:

'we tend not to get into the really big journals, you know, the Nature and Science, it is difficult to get into the New England Journal, but that is again partly because of the quality, I think, and partly because we just need people looking at the clever molecular cellular things or judge ours with new drugs, and we do not do that sort of stuff.' (GA)

Another issue is the peer review process and the time it takes to be completed, causing delays in publishing the studies' findings:

'There is also now a growing bureaucracy associated with publication of papers as well. Nowadays, first of all when you write the paper, many journals are now requiring you either provided detailed information to a pre-set format, you know, so if you do a cohort study or RCT, you are expected to provide documenting, provided each of these bits of information. They are not always appropriate to all studies anyway, but it is doing writing papers by numbers really.' (AF)

Publishing negative results could also be challenging, but this issue is experienced in other fields as well:

'There is the usual issue about publishing the negative findings, which are just null, but that is a problem across the whole of medicine.' (GA)

Reported facilitators

The study participants reported the following strategies that they employed to facilitate their studies:

Effective communication with relevant stakeholders before and throughout the study conduct. Stakeholders included (depending on study type and setting); industry management or employers, trade unions, work representatives, workers or employees, ethics and governance bodies. Communication involved meetings (e.g., attending ethics committee meetings, meeting workers or management), and preparing written materials (e.g., leaflets, study information and advertisements, online information):

'A lot of input from me communicating with the workplaces, the workers, the unions. I did need them all for a lot of ground work from that aspect that was really very important..... before, all of it before, and I kept, once I got them on board and understood why I am doing the study, how the results will be used, and I kept in touch during the study as well. And I have sent summary of the results afterwards.' (FM)

Cooperation, support and interest of the relevant stakeholders. For example, the support of trade unions can sometimes be crucial to get the cooperation of the industry or employer as well as the workers:

'Other studies, in which the whole industry, you had sort of influential trade organisation, and they were able to galvanise all the individual companies to take part in a uniform way.' (AD)

Government, media, and public interest in the issues under investigation:

'Well I think there was a public expectation that it would be done. Because we said we were going to do it, following on the initial study and so we were being reminded by certain people from time to time, you know, you said you are going to do this where are the results. And that I guess sort of was filtering through to the people who had to allow us or not to use the information and had to understand why we are doing it and so on.' (AB)

The availability and completeness of workers or employees records:

'A particular factory I studied that had records going back to when the factory was opened in 1920's. But that is quite unusual.' (AD)

'So and again it's the quality of the work histories which will then decide how sophisticated the analysis can be, in terms of whether you can estimate chemicals exposures to different things and so on' (AD)

Availability of resources including funding and appropriate researchers to work on the study.

Rigorous study design including appropriate research questions.

5.4.2.2 Level two analysis results

In-depth and systematic analysis of the data revealed that this field is currently facing serious challenges. The primary issue is the lack of human and financial resources and the other issue is that the challenges are increasing over time. Both themes are interlinked and will be discussed in the next sections.

Lack of human and financial resources

Participants indicated that this field is seriously under resourced in relation to human, financial and infrastructure. For instance, it has been reported that few key researchers have left the field, and that those remaining are getting older; younger researchers are few and difficult to recruit; and there is a shortage of expertise in specific areas within this field. It was clear that the community is small. This issue was also confirmed by the study participants, and when asked to identify other participants, most of them referred to the same researchers.

Furthermore, respondents reported a lack of investment from educational bodies in developing research and educational programmes in this field. There are only few universities' departments that are dedicated to this field, and those are more likely to be peripheral to the environmental or other epidemiological fields. This inadequate support of the OE research field from public, private and charitable sources sends strong negative signals to young researchers planning their careers.

Interestingly, some respondents felt that OE was less attractive to stakeholders to invest in because it mainly employs classical methodology, and therefore, it is seen as an old fashioned field that lacks innovative methodologies and techniques. This was felt to influence the wider scientific community in believing that this type of research was not worth attention, the funding, and the investment. This point is addressed further below.

As a result of the challenges, participants felt that the number of good quality studies within OE is not as high as it used to be, and that this deterioration has contributed to the challenges researchers are currently facing:

'And I think that is one of the problems we, UK has done good quality research over the years, but now there is just fewer, and fewer of us are doing it. And that is a real problem. Or at least there are fewer institutions that have got a good core group, and we are old. So until we can get the younger people coming up, that is going to be difficult to do that. We have to do good quality research to make people say wow, I want to do that, and it is worth doing. Because it is worth doing, you know, the whole relationship rank between work and health as there are so many gaps now not reached that would be hugely to the benefit of mankind, if we can actually fill some of these gaps.' (GA)

Why it is difficult to get OE research funded?

One of the reasons cited for the difficulties in getting funds is that OE research uses mostly classical methods, and does not employ cutting edge methodologies or techniques such as molecular and genetic techniques. As a result, OE is perceived to be less innovative and therefore is not attractive to funding bodies:

'A lot of it (occupational epidemiology) uses techniques that most people would find very old fashioned and that is not attractive to a lot of funding bodies.' (AE).

'I have yet to see in this meeting (EPICOH), for instance, anything particularly innovative. It has been interesting but I have seen nothing made me step back and say wow that is a real step forward, in terms of methodology. It is all variation on a theme really, and that is where we need to go.' (GA)

At the time of the interview, one of the study interviewee's grant application submitted to the MRC for one of his projects was not successful. The participant justified the MRC refusal to fund the project by not including cutting edge technology in the study:

'I have just lost a grant to the MRC despite very good reviews. I think that was because it did not include any cutting edge technology. I know it should have, but for that reason it is not attractive to them, even if you could persuade them there is a big important problem, which is. So funding is a problem.' (AE)

Another participant provided similar justification for the lack of MRC funding to this field:

'They (MRC) often say to us, well give us good quality research and we will fund it. Well, we know that they have had good quality submissions, and just they have not funded it, and

they have not funded it very often, because it does not include cells or molecules. They are just not particularly good at thinking about some of these things.’ (GA)

Another reason indicated by the participant is that the National Institute of Health Research primarily funds research towards the benefit of patients. However, in OE the target populations are typically workers and employees who are regarded as healthy:

‘NIHR they again they say they like to do it, but there is no signs of them doing it, and you know all their literature refers to patients, but people in a factory are generally not patients. So there are real problems funding wise.’ (AE)

‘...the NIHR has few funding opportunities for occupational health, and that it is (NIHR funding) pretty much for patient benefits, they do not see staff as patients; whereas the NHS staff are our patients, but the NIHR wont fund. So that is quite difficult.’ (FM)

How could researchers improve funding of OE research?

It is not only important to get OE research funded, according to participants, but also it has to be sufficiently funded. Otherwise, it will not be of a good quality research. Consequently, this will affect more severely the field’s reputation of not been able to produce high quality research, and to be regarded as an old fashioned and that lack innovation and cutting edge techniques and methodologies:

‘...you have to get properly funded decent research, and if you try and do it in a shoe string, you will end up with poor quality research. That is the end of it’. (GA)

Once a researcher has secured funding for a particular project, it is very difficult to rely on other sources to complete the project. Therefore, the participants’ advice is to make sure the study is cost up properly before applying for funding:

‘...if you try to rely on the University or institution, oh, I need a bit of money for this, and I need a bit of money for that. The Universities are also having tightened their belts, and they will say no, you should have put that into your grant.’ (GA)

For application to general funding bodies, there is very competitive environment and researchers have to make OE research more attractive to funding bodies to be able to successfully secure funding. One way of making OE more attractive to funding bodies according to some of the participants is through incorporating new cutting edge technologies and methodologies:

‘I think over the next 5-10 years we will be seeing more and more work where you can link in the new molecular stuff, molecular epidemiology, particularly using human genome technology, and I think then occupational epidemiology will be able to take another step forward,’ (GA)

Furthermore, to make occupational research more attractive to funders, OE researchers need to collaborate and establish a wider network in work and health research, bringing in areas

that are not necessarily always regarded as being involved in occupational research, but have more knowledge and skills in the new techniques and methodologies:

'The epidemiologists need to talk more with the mechanistic people, understanding the mechanism of disease, and also on the other side the effects of work on health. So issues around involving social scientists, labour economists, health economists. These sorts of people who have been peripherally, if at all involved in occupational research. They will start or should start becoming more involved, that is the only way forward.' (GA)

OE researchers also need to work together to lobby the funding bodies and persuade them to fund OE studies:

'I think they (OE researchers) should put together a priority list of research in occupational health and lobby the NIHR to fund those.' FM.

'So one solution will be to persuade some of the funding bodies, particularly the big boards, that this area, which they should be investing in it.' (AE)

Challenges are increasing over time

Respondents felt that it is more difficult to conduct OE studies than in the past, and that the challenges are increasing according to the participants. Participants were inclined to compare carrying out studies in the past with nowadays. Most of the difficulties they have encountered either did not exist before, or have increased over the years, and some are expected to get worse in the future:

'...in the present time there are big challenges to get research done, which arise from the governance process that's now in place, which did not exist in the past. Years ago for an occupational epidemiology project, basically if you could persuade the company, and the workforce that a project was worth doing then beyond that all you had to do is to persuade something called the BMA (British Medical Association) research ethics committee..' (AB)

'I suppose I 'd have to say the studies in the early days, which in 1970's and 1980's, were easiest to set up because then getting permissions was straight forward, and of course it has become increasingly a bureaucratic nightmare to do anything useful' (AD)

The above researchers were referring to ethics and governance approvals difficulties. Nonetheless, recruitment of participants has also become more challenging and includes the decline in response rate as discussed previously. In addition, getting OE studies published in highly ranked journals has also become more difficult:

'And the second problem, common problem of course, is getting money..... I think it is probably getting worse (securing funding for OE research)' (AE)

'There is also now a growing bureaucracy associated with publication of papers as well. When I first started it was fairly straightforward' (AF)

5.4.3 Discussion of the qualitative phase results

The interview study revealed that OE field is currently facing many challenges. The most important challenges are; lack of funding and support to this field, lack of innovative/new

methods and techniques, and challenges related to ethics and governance frameworks in the UK. These key issues are discussed next. Further analysis is provided in the main discussion section of the first two phases of this study.

Results from this phase of the study provided evidence that responders believed that OE has not been sufficiently funded compared to other epidemiological and other health disciplines, as the discipline has been unable to compete for public funds against more established and newer fields. The government had made little provision for research or for training in the OE field (Coggon, 1999, 2005). The Institute of Occupational Medicine (IOM) underlines the decline in the number of posts in occupational medicine, and the fewer doctors seeking training (Coggon, 2005). This level of academic infrastructure was not believed to be sufficient to sustain the maintenance of the highest academic standards and research quality. It was also weakened by the educational, governmental and other research-funding bodies' lack of investment and support in developing well-established programmes. Indeed, Guidotti (2000) argued that the existing information base derived from OE is rapidly becoming obsolete for identifying possible association between new potential occupational risks and diseases.

Occupational epidemiology is lacking innovative methodology, according to the study participants. They have recommended a better collaborative approach with other disciplines to be able to include more innovative methods, and tools. It mainly employs classical methodologies making it less attractive to funding bodies. In particular with the developments in methodological approaches in other health disciplines (Ward et al., 2003), it is getting more challenging to compete for funding opportunities or attracting younger researchers, who might prefer a more dynamic and cutting edge research field. One of the explanations for OE is not sufficiently employing new cutting edge methodological approaches, is that the key researchers in the field are the older generation whose main experiences are focused on the classical approaches.

This was also due to a common perception that most major occupational carcinogens have already been identified (Ward et al., 2003). In the USA, the National Occupational Research Agenda (NORA) has emphasised that, although there have been multidisciplinary efforts to develop cancer research methods, these have not been broadly utilised to solve important issues within occupational cancer field (Ward et al., 2003). One of the interview participants, who work in the area of occupational cancer, provided similar insights. The NORA, have recommended methodological development to include innovative methods

and tools within OE research and risk assessment (Ward et al., 2003). This need was also recommended by occupational health stakeholders in a recent Canadian study (Hohenadel et al., 2011) and by this study's participants.

For this field to develop there is a clear need to train capable individuals in the use of new methods and techniques such as molecular and genetic epidemiology to be able to address questions arising from the interface of molecular/genetic biology and epidemiology. Molecular and genetic epidemiology training requires practical application of both the laboratory and epidemiologic techniques. The molecular epidemiologist will need to collaborate with clinicians, statisticians, epidemiologists, molecular biologists, computer scientists, engineers, and practitioners in the fields of bioinformatics and computational biology (Foxman & Riley, 2001).

The UK ethical and governance frameworks were thought to have caused challenges to health research, particularly for epidemiological studies. These issues were also emphasised by the OE researchers who participated in this study. Doll in reference to these issues, showed how it was relatively easy to access data and participants for epidemiological research, and provided a dramatic view of the effect of these issues on the future development of epidemiological fields:

'...There has been an enormous change in the attitude towards confidentiality. I wouldn't say that it was a change in the public attitude, so much as in the governmental attitude, because I am not sure that the public is really as concerned as governments appear to be. When I started in epidemiology, we operated on the old system, which was approved by the Medical Research Council, that a doctor could pass information about a patient to another doctor, relying on the fact that he or she would be bound by the Hippocratic oath to treat details about patients confidentially. We had no difficulty in collecting all sorts of information as long as the process was covered by someone medically qualified. I say "covered by" because quite often the statistician would be the one actually handling the data but, in order to meet the conditions at the time, you had to have a medical person accepting the responsibility for the confidentiality of the data. This system worked perfectly well, and I know of no trouble having been caused for anybody by the free passage of information between clinicians and epidemiologists for the study of disease.

Now it is becoming horrifyingly difficult to get hold of epidemiological information relating to individuals, and I can see great difficulties for the epidemiologists of the future. I didn't immediately mention this point when you first asked about risks faced by our profession because I find it so depressing that I have suppressed it in my mind. It won't affect me, as I won't be involved in research in 10 years' time, but valuable research of importance to the public health really is being made extremely difficult, if not impossible in some cases.' (Darby, 2003, p. 378)

5.4.4 Summary

This qualitative interview study explored key UK-based OE researcher' perceptions of the challenges to and facilitators of OE research in the UK. Key researchers shed some light on these issues. The issues reported by key researchers were tested within the general OE community members in the next phase of the study, which was a quantitative survey based on the findings of the review and interview phases.

5.5 Part 2: Survey of UK-based OE researchers

5.5.1 Introduction

The previous phase of this study utilised a qualitative methodology to explore among key UK-based OE researchers the challenges and the facilitators of OE research. It provided a clear picture of the barriers to, and facilitators of conducting OE studies. However, the qualitative study imposes limitation in relation to the generalisability of the study findings, due to the small number of researchers interviewed. Therefore, a survey was undertaken to examine the research topic with a larger population of OE researchers in the UK, as well as to assess whether they had also encountered similar issues.

A quantitative approach utilising a survey (Creswell, 2009) was selected as the method to examine the perceptions of the UK wider occupational epidemiology community of the challenges and facilitators of OE research. In the following sections the study design is discussed including sampling strategies, questionnaire design and data analysis techniques. Next, the survey results followed by the discussion sections are presented.

5.5.2 Quantitative Phase methods

5.5.2.1 Sampling

The target population in this survey is the UK-based OE researchers. In the absence of a suitable sampling frame covering the whole community, a convenience sample (non-probability) was preferred (Bowling & Ebrahim, 2005). In other words, it is impossible to identify all eligible OE researchers in the UK. Additionally, not all researchers who conduct OE studies are necessarily OE researchers. Therefore, a pragmatic approach to sample selection was followed and a convenience sample was favoured.

5.5.2.2 Sample size and setting

The number of researchers in this field is small. It is also difficult to estimate the number of researchers in this field. FOM (2011) estimated that there were an estimated 27 full-time equivalent academic posts in occupational Medicine. This number, however do not include other academics such as statisticians and epidemiologists. Overall 144 OE researchers were

invited to take part in the current study. From those, 83 potential participants were handed the questionnaire at the International Conference on Epidemiology in Occupational Health (EPICOH) conference, held in Oxford in September 2011. The other 61 participants were identified by screening websites of relevant universities' departments, governmental bodies and other institutions and by snowball sampling; by asking participants to identify other potential participants. Participants were chosen based on their profiles and/or published work. Criteria for inclusion dictated that each participant was an active researcher/stakeholder in the field of OE. No restrictions were applied on the type of work or roles that these researchers have been involved in; hence, various professionals within OE were included; such as statisticians, epidemiologists, and health professionals. Based on the extensive search, discussed above, to identify those by the researcher, it is likely that they are less than 200 individuals in the UK.

5.5.2.3 Questionnaires

Questionnaires-based method is a common approach of covering a large population. They are quicker and more economical than interviews. They also reduce bias compared to interviews and are useful when questions are simple and direct (Bowling & Ebrahim, 2005). The study questionnaire packs included pre-paid addressed envelopes, and a cover letter; explaining the study and contained instructions to post the questionnaire once completed. One of the main disadvantages of postal questionnaires is that the response rate may be low due to the non-return of questionnaires (non-response bias) (Bowling & Ebrahim, 2005). To improve the response rate in this study, advert posters were placed at different advertising boards at the EPICOH conference. Furthermore, two reminder letters sent out to all participants within two to four-week window to complete the questionnaire. The questionnaire was also completely anonymous; therefore, these reminder messages were sent out to all invited participants, including those who had already submitted their responses. The reminder letter also included the questionnaire pack as described above.

Development of the Questionnaire

Questionnaires are important tools for generating data; hence, development of the questionnaire for this survey involved several considerations, particularly choosing the questionnaire design and the development of the questionnaire's statements. There are many types of attitude scales such as Thurstone scales, Likert scales and others. Foddy (1994) argued that Likert scales have been used more widely than any other rating scales for measuring attitude. Therefore, this scale was used in the survey to examine UK-based OE researchers' views regarding challenges and facilitators of OE research in the UK.

Streiner and Norman (1995) stated that, in social science, the questionnaire statements for a scale are usually derived from four sources: theory, research findings, clinical observation and input from patients. In this study, the statements were developed based on the themes identified in the qualitative interviews (developed from the participants' statements) and from the literature. The next step was modifying these items by removing or modifying some words, for example, removing leading or ambiguous words or statements and identifying those with double meanings (Oppenheim, 1998). The questionnaire items were discussed with the supervisory team and tested with an external survey design expert (no modifications were needed). It includes 28 Likert-style challenges and facilitators statements (each with a five point scale from strongly agree to strongly disagree), nine open ended questions about their perspectives of the impacts of the challenges and strategies employed to overcome such challenges, and six demographic information questions (Appendix B-5). The participants were asked to rate their agreement with each statement, and to complete the open ended questions.

5.5.3 Quantitative Phase Analysis

The Statistical Package for Social Sciences, SPSS version 19 (SPSS Inc., Chicago, IL) was used to code, organise and analyse data and then to derive summary statistics related to the barriers and the facilitators' statements and to compare similarities and differences between responses, as well as to summarise demographic data. Nominal categories were coded by defining and labelling each of the variables and assigning numbers to each of the possible responses. The SPSS data matrix was screened and cleaned for any anomalies in order that a valid and reliable dataset could be analysed. In addition, a specific number was assigned to a postal response so that it could be referred to again if required. Simple descriptive statistics were used including means for continuous variables, and frequencies and percentages for categorical variables. Thematic analysis was used to analyse the open-ended questions.

5.5.4 Reliability in Quantitative approaches

Reliability refers to consistency and repeatability of the measurement within the research carried out. Quantitative approaches to data collection and generation are generally associated with increased reliability (Shih, 1998). In this study, consistency can relate to the questionnaires being clear and well defined in order to reduce the possibility of misinterpretation by the respondents. The chances of this occurring were reduced by the involvement of statistics expert members of the supervisory team (DMM and CJS) in building the questionnaire and formulating the questions. Additionally, the questionnaire was piloted with the OE field's expert (DMM) and an external quantitative field expert.

5.5.5 Quantitative Phase Results

5.5.5.1 Description of sample

Two potential participants returned a blank questionnaire and a note stating that they are not suitable candidate to participate, and another three blank without any notes (which may indicate they are also not suitable candidates). After excluding those blank questionnaires, the overall response rate was 36.5% ($n = 53/144$).

The majority of the participants had earned a PhD degree ($n = 37$; $\mu = 70\%$) as their highest professional degree, followed by MSc degree ($n = 9$; $\mu = 17\%$), and undergraduate degree ($n = 3$; $\mu = 5.7\%$), and other qualifications ($n = 2$; $\mu = 3.8\%$). As shown in Table 5-1, approximately two third of the participants have 10 years or more of experience ($n = 34$; $\mu = 64.2\%$), and one third have less than 10 years of experience ($n = 19$; $\mu = 35.8\%$).

Table 5-1: Length of participants' experience

Length of the participants' experience (in years)	Number of the participants	Percentage
Missing	5	9.4
3	2	3.8
4	3	5.7
5	3	5.7
6	4	7.5
7	1	1.9
8	1	1.9
10	9	17.0
12	1	1.9
13	3	5.7
15	5	9.4
17	1	1.9
20	5	9.4
22	1	1.9
25	1	1.9
30	5	9.4
33	1	1.9
35	2	3.8
Total	53	100.0

More participants are working at universities ($n = 24$; $\mu = 45.3\%$) than in governmental bodies ($n = 8$; $\mu = 15.1\%$), and Research Institutes or charity ($n = 7$; $\mu = 13.2\%$). As shown in Table 5-2, the majority reported working as epidemiologists ($n = 16$; $\mu = 30.2\%$), and physicians ($n = 11$; $\mu = 20.8\%$).

There is a huge variation in the field of work of each participant. They work in many different areas including; musculoskeletal diseases, mental health, cancer, respiratory, surveillances, exposure assessment, shift-work, health service research, ergonomics and other occupational health areas not specified.

Table 5-2: Participants' Roles

Participant's Role	Frequency	Percent
Epidemiologist	16	30.2
Physician	11	20.8
Occupational Hygienist	5	9.4
Statistician/Epidemiologist	5	9.4
Statistician	4	7.5
Nurse	1	1.9
Other	10	18.9
missing	1	2.8
Total	53	100.0

5.5.5.2 Research Challenges

The main challenges identified (see Appendix B-6) were; low response rate ($n = 46$; $\mu = 86.8\%$), workforce records issues (inaccessibility, inaccuracy and incompleteness, and early destruction) ($n = 43$, $\mu = 82.7\%$; $n = 36$, $\mu = 67.9\%$; $n = 22$, $\mu = 42.3\%$, respectively), lack of funding ($n = 38$; $\mu = 73.1\%$), accessing data and participants difficulties including; obtaining ethical and governance clearances, the length of time access agreement takes, and permission to access the data/participants (ranges from 28.8% to 69.6%). Additionally, to a certain extent, finding experts in certain areas of OE was perceived to be difficult (48.9%). In contrast, only small numbers of respondents agreed with the statements relating to challenges in publishing research findings (3.8%- 25%) (Appendix B-6).

5.5.5.3 Research Facilitators

The highest level of agreement with suggested facilitators (see Appendix B-7) was the government interest in such study to be carried out ($n = 48$; $\mu = 92.3\%$). Almost all participants agreed that good communication with relevant stakeholders is important to obtain approval and cooperation ($n = 46$, $\mu = 88.5\%$, and $n = 44$, $\mu = 84.6\%$, respectively). This is followed by exploiting data from previous large epidemiological studies ($n = 43$;

$\mu=81.1\%$) and support from trade unions/work representatives ($n = 42$; $\mu = 80.8\%$). The following issues were also considered important to facilitate research studies but to a lesser extent than the previously mentioned issues: studies designed to fill out gaps related to government issues or policies, media pressure; studies on behalf of regulatory bodies; and media role in improving response rate (range from 51.9% to 67.3%) (Appendix B-7).

5.5.5.4 Survey open-ended questions results

Additional challenges

Participants were asked to mention any other challenges that were not stated in the challenges statements. Twenty-three participants answered this question, yet only 3 additional challenges were added. This included the lack of government interest in this field ($n = 4$), lack of career structure for young researchers ($n = 3$), and lack of researchers time due to other work commitments ($n = 1$). The rest were already stated in the challenges statements (see Table 5-3).

Table 5-3: List of additional challenges to OE research and number of responses

Additional challenges	Number of responses
Lack of researchers and expertise	9
Funding issues	8
Employer or industry agreement	3
No interest	3
Record issues	3
Recruitment issues	3
Career structure	3
Ethics and governance	1
Publication	1
Time constrain	1

Most important challenges

Participants were then asked to state which of the challenges they consider the most important and why. Thirty-one participants answered this question (Table 5-4). The most important challenge according to the participants is lack of funding bodies and opportunities in this field, because without the fund, such studies cannot be conducted ($n = 14$). In this regard two participants thought the majority of the funds are allocated to molecular and genetic fields. Another two participants commented on the reduction of funding from HSE and criticized the HSE funding policy of sub-contracting most of their research to Health and Safety Laboratory (HSL).

Table 5-4: Challenges considered being the most important

Most important challenge	Number of responses
Funding	18
Ethics and governance	12
Recruitment issues	8
Records issues	7
Difficulty in getting management/employer agreement	5
Lack of government interest in this field	2
Methodological issues	2
Lack of career structure	3

The second most challenging issue was obtaining ethical and governance approvals mainly from the NHS ($n = 12$). The inconsistent interpretation of ethical and governance frameworks was particularly an issue, as well as, the multiple and complex forms and applications to different bodies to be able to get approvals. They all complained about the length of time this process can take and consequently the waste of resources; researchers time, money and delay in recruitment. A noticeable comment is regarding the lack of knowledge among ethics committee members of OE studies and settings; as a result, inappropriate decisions were made such as imposing unrealistic measures in place to conduct the study, which could jeopardize the study.

Recruitment difficulties mainly low response rate and difficulty accessing records and incompleteness of data were also considered important because both can affect the study findings validity and the ability to draw strong conclusions. Additionally, management and employer agreement to conduct the study was considered important, which requires time and effort (i.e., a lot of communication and persuasion with different people). Finally, lack of career structure, methodological difficulties (e.g., conducting cohort studies, and sample size and power), and lack of government interest in this field were other important challenges yet were not emphasised by many participants.

Strategies employed to overcome the challenges

Additionally, participants were asked what strategies they employed to overcome the challenges, the reason for that, and whether they were successful. Thirty-six participants answered this question. The main strategy researchers used to overcome the challenges they encountered was changing study design ($n = 12$). For example, some participants anonymised the data or the study questionnaire, and few requested only mortality data rather than cancer registration details. The main reason for this was to deal with ethical and governance clearances challenges and due to funding constrains.

The second most strategies employed were using recruitment strategies to improve participation rate, communication with relevant stakeholders. Attending ethics committee meetings when their studies were being discussed to overcome any delays of the study clearances and set up, being persistent in dealing with the challenges, and reapplying for funding were also strategies used by researchers. Other strategies were stated but were not as frequent as the ones mentioned above (see Table 5-5). Most participants said they were to some extent successful, but some strategies had imposed some limitations to the study design and results, and increased the time and cost of the study.

Table 5-5: Strategies employed to overcome research challenges

How overcome challenges	Number of responses
Change study design	12
Recruitment strategies	5
Communication	5
Attend ethics meetings	4
Persistence	4
Re-apply funding	4
Deal with ethical issues-proposals	3
Appeal against refusal decisions	3
Dealing with missing data statistically	2
Use university ethics instead NHS	1
Non UK expertise and collaboration	1
Data from other large epidemiological studies	1
Advice from senior researchers	1

Additional facilitators

Five participants responded to the question about adding more facilitators; however, none of their responses represent any new facilitators and mainly repeated some of the ones included in the facilitator statements.

Most important facilitators

Participants were asked to mention the most important facilitator and the reason for that. Thirty-five participants answered this question (Table 5-6). The most important facilitator was getting support from trade unions/work representatives because, according to participants, it facilitated and improved recruitment of study participants. Similarly, important facilitator was government interest in a particular study to be conducted as this facilitates funding and access. Secondly, using data from large epidemiological studies was important because studies on existing cohorts are a very efficient and cost effective way to conduct research. Thirdly, pre-study negotiation for relevant stakeholders' approvals is important to facilitate access to data and participants. The fourth important facilitator was

carrying out studies by or on behalf of relevant regulatory bodies such as HSE. Because such studies are easier to get approvals by relevant stakeholders, and perceived to have more value and thus workers/employers are keener to participate. Besides, keeping stakeholders involved by good communication through the study phases and conducting studies designed to specific gaps government policies because it attracts funding and support from all relevant stakeholders.

Table 5-6: Facilitators considered being the most important

Most important facilitators	No. of responses
Support from trade unions/work representatives	10
Government interest and pressure for a particular disease/problem to be investigated	10
Data from large epidemiological studies	9
Pre-study formal and informal negotiations and discussions with relevant stakeholders	8
Studies carried out by or on behalf of the relevant regulatory bodies	7
Keeping stakeholders involved by communicating with them about the study	4
Studies that have been designed to specific gaps in government or other policies	3

Studies that prematurely stopped, compromised or considerably delayed

Furthermore, participants were asked if any of their studies have been prematurely stopped, compromised or considerably delayed (Table 5-7).

Table 5-7: Researchers answers to whether their studies were prematurely stopped, compromised, or delayed

Question	Number. answered 'yes'	Number answered 'no'	Total
Have you prematurely stopped any of your studies?	8	31	39
Have any of your studies been compromised?	9	31	40
Have any of your studies been considerably delayed?	30	14	44

Eight researchers were forced to prematurely end their studies mainly due to difficulties recruiting workers. Another nine researchers said their studies were compromised due to

poor response rate limited funding, and ethics and governance clearance delays. In terms of study delay, 30 participants experienced studies delays primarily because of ethics and governance approvals delays and recruitment difficulties (Table 5-8).

Table 5-8: Reasons for studies’ delays

Challenges caused study delay	No. of participants
Ethics and governance clearance	17
Recruitment issues	5
Funding issues	3
Industry management agreement	2
Work constrain and time management issues	2

Publication challenges

Finally, participants were asked whether they have experienced difficulties in publishing the findings from their studies. Thirty-eight participants replied; from those 11 have experienced publication difficulties due to various reasons including articles’ reviewers did not accept publishing negative results, difficulty from industry/employer, funding constrains, and limited number of journals interested in this field output. However, some of them despite the difficulties, they were able to publish their findings (e.g., convinced industry to agree on publishing the study results).

5.5.6 Discussion of the survey phase

This phase of the study supported the previous phases’ findings. The interview participants in this study reported the key challenges to conducting OE research in the UK including; getting funding, data and participants access, and lack of expertise, records issues, recruitment difficulties, and publication issues. Additionally, they have identified the facilitators, strategies they have employed to overcome some of the challenges, and recommendation to improve carrying out this type of research in the UK. These issues were tested in this subsequent quantitative phase by utilising a questionnaire; specifically designed, using SR and interview phase findings, to be used for this study. The participants of the survey phase confirmed these issues with slight variations on the emphasis of the challenges and the facilitators.

The findings from the three phases of this study are discussed in next part of this chapter.

5.6 Part 3: Discussion of the overall study findings

Key issues are identified in this two-phase mixed method study as important, which are discussed in the following sections:

- **Lack of human and financial resources**
- **Declining interest in OE field**
- **Lack of expertise and cutting edge methodologies and techniques**

A summary of the findings is also presented at the end of this section.

5.6.1 Lack of human and financial resources

Overall, the findings revealed that OE is currently facing many challenges and among those challenges, lack of human and financial resources is of utmost importance. Despite the continuous work related illnesses and injuries and thus the need for OE studies, this field is seriously under resourced in relation to human, financial and infrastructure. For instance; there are few key researchers left, and they are getting older; younger researchers are few and difficult to recruit; and there is a shortage of expertise in specific areas within this field. As a consequence of all the challenges, the community within this field is getting smaller, scattered and has become increasingly less powerful and influential.

It was clear that the community is small when the study questionnaire was distributed; it was difficult to identify many researchers in this field, and most of those identified were not purely OE researchers, but contribute to other areas such as environmental epidemiology and randomised controlled trials (RCTs). This issue was also confirmed by the study participants who indicated that OE community is small, and when asked to identify other participants, most of them referred to the same researchers. Furthermore, the Institute of Occupational Medicine (IOM) highlighted the decline in the number of posts in occupational medicine, and indicated that fewer doctors are seeking training (Coggon, 2005). This can be an indication of lack of investment leading to a troubled career path in this field as shown in this study.

5.6.2 Declining interest in OE field

The lack of human and financial resources in this field is also likely to be due to relevant stakeholders' declining interest in this field. The main cited reason was that OE is less attractive to stakeholders to invest in; and thus has less funding opportunities and few academic institutions that are providing training and education.

The lack of funding bodies and opportunities for OE research, and the reduction of stakeholders (e.g., government, funding bodies, and academic institutions) interest in this field can be partially explained by the perception that the improvement and establishment of workplace exposure standards and policies are reducing diseases and accidents. For example, asbestos importation, supply and new use were totally banned in the UK since 1985 (Chen & Osman, 2012). Therefore, control of exposures is probably seen as the end point of the disease prevention effort, because, at this point, causality has been established and measures have been taken to restrict exposure (Blair, Hohenadel, Demers, Marrett, & Straif, 2013). Additionally, there is an evidence indicating that removing or reducing exposure will usually result in decreasing symptoms and risk; for example the reduction of cancer risk after tobacco smoking cessation (International Agency for Research on Cancer, 2011). Moreover, Cherrie (2009) concluded that there is 8% decline per year in exposure for most of main current carcinogens, and estimated that the UK future burden from occupational carcinogens exposure could be reduced from approximately 7000 to 2000 occupational cancer deaths per year within the next 20–30 years.

Another important factor that could have influenced the government interests and the availability of funding for OE research is the sharp decrease in workers employed in industries and occupations in which certain hazards have been found in the past (e.g., mining and rubber industries) and the increase of service industries (e.g., banking, sale and retail industries) in the last decade (Boffetta & Kogevinas, 1999).

These two parallel issues (i.e., decrease in exposure and heavy industries) have most probably led to the conclusion that many occupational risks (particularly occupational cancer risks) in developed countries are only a problem of the past (Boffetta & Kogevinas, 1999). Although this is probably true for the traditional large-scale industrial sector, such as the mining industry, many hazards at workplace are suspected and others have not been removed (Chen & Osman, 2012). In 2007, Shift work, for instance, was classified as probably carcinogenic to humans based on limited evidence for increased risk of breast cancer (Cogliano et al., 2011).

Blair et al. (2013) highlighted that the number of suspected occupational carcinogens identified from 1964 until 1982 increased by about 1000% (9 to 92), whilst between 1982 and 2003 the increase was approximately 50% (92 to 137). The authors hereafter concluded that this decrease in newly identified occupational carcinogens is a reflection of insufficient and slow current scientific efforts in this field in developed countries. They further added:

'It is our impression that the number of investigators engaged in the study of occupational cancer has decreased considerably over the past two or three decades. The number of papers on occupational cancer in general epidemiology meetings seems considerably fewer than 30 years ago. Research units in academia, government, and industry focusing on occupational cancer may have also diminished.' (Blair et al., 2013, p. 3).

Although the above authors were referring to OE in cancer and in developed countries; nonetheless, their conclusions matched those of this study participants regarding OE field in the UK. It is not clear whether this decline of interest in OE is global; similarly, there is no sufficient evidence to prove these conclusions are true globally or in the UK.

Notwithstanding, few authors argue that there is a declining interest in OE field in other developed countries (Hohenadel et al., 2011; Derek and Leggat, 2006). This is due to the misconception that work-related conditions have been adequately addressed in the developed countries. This also may indicate that policy makers and funding bodies have prioritised other epidemiological and clinical fields. For instance, Derek & Leggat (2006, P 70) argue that *'Although great strides have been made in occupational health services during the past 200 years, a continuous decline in funding for worker's health research poses probably the most serious challenge in contemporary Australia, and one that continues into the new millennium'*. Furthermore Hohenadel et al. (2011) conducted a survey of a broad range of Canadian stakeholders in the field of occupational cancer. The study highlights the main challenges of occupational field in cancer in Canada. These included insufficient funding, lack of data on exposures and outcomes, lack of awareness about occupational cancer issues, employer/industry resistance, methodological challenges, low public and political priority, and lack of collaboration (Hohenadel et al., 2011).

Furthermore, there is a lack of investment from educational bodies in developing research and educational programmes in this field. There are only few universities' departments and organisations (i.e., HSE and Institute of Occupational Medicine (IOM)) that are dedicated to this field, and those are more likely to be peripheral to the environmental field. In addition, these few academic departments might not be sufficient to sustain the maintenance of the highest academic standards and research quality. This inadequate support sends strong negative signals to young researchers planning their careers, which adds to the declining number and expertise of OE community.

5.6.3 Lack of expertise and cutting edge methodologies and techniques

Developments in the primary infrastructure of national statistical data have led to better understanding of the major determinants in health (Holland, 2002). Data became available from health surveys, disease surveillance and the results of large, long-term population based studies. This was evident in the systematic review and survey findings, which showed that 13 studies ($\mu = 38\%$) had utilised data from previous large and well-designed epidemiological studies, such as; the Whitehall II study (Marmot and Brunner, 2005), and 8 studies ($\mu = 23\%$) were completely reliant on readily available data, which were collected for different purposes and from various sources. The majority of the survey participants (81%) agreed that using data from such sources facilitates research.

The availability of these data has led to methodological developments that have been applied to occupational health problems. Examples of such methodological developments are; toxicology and risk assessment; molecular and genetic epidemiology; meta-analysis and cross-design synthesis; measurement of disease burden; national health surveys and demographic surveillance studies (Checkoway et al., 2004). This development requires scientific input from more than one discipline, depending on the particular issue in question. This may include a range of scientists with initially little in common and who may not share working approaches.

Moreover, scientific understanding of the mechanisms of carcinogenesis, accompanied by the development of assays for studying mechanistic events involved in carcinogenesis, have given researchers new ways of establishing whether an agent is carcinogenic. This notion is increasing and has been supported by IARC, and since 1991, it has given similar confidence of carcinogens classifications based on strong mechanistic evidence in exposed humans and classifications based on sufficient evidence from epidemiological studies of cancer in humans (Cogliano et al., 2011) However, such developments according to the study participants have not been sufficiently utilised in OE field.

The study participants for instance recommended a better collaborative approach with other disciplines to be able to include more innovative methods, and thus making OE field more attractive to funding bodies. In particular with the developments in methodological approaches in other health disciplines (Ward et al., 2003), it is getting more challenging to compete for funding opportunities or attracting younger researchers, who might prefer a more dynamic and cutting edge research fields. In the current study, one possible explanation for OE being not sufficiently employing new cutting edge methodological

approaches is that the key researchers in the field are the older generation whose main experiences are focused on the classical approaches. Likewise, the majority of the study participants are epidemiologists, physicians or statisticians (~67.5%) which reflect the lack of multidisciplinary in this field in the UK. This may explain the lack of expertise required to advance the methodological approaches and techniques such as molecular and genetic techniques, psychosocial and health economist approaches. Then, the question is whether this type of research is really not innovative, or is it just a perception of its community members, becomes obvious.

In the USA, it was emphasized, by the National Occupational Research Agenda (NORA), that although there have been multidisciplinary efforts to develop cancer research methods; these have not been broadly utilised to solve important issues within occupational cancer field (Ward et al., 2003). This was due to a common perception that most of significant occupational carcinogens have already been identified (Ward et al., 2003). One of the interview participants, whose main research is in the area of occupational cancer, provided a similar explanation. The NORA, then recommended methodological development to include innovative methods and tools within OE research and risk assessment (2003). This need was also recommended by occupational health stakeholders in a recent Canadian study (Hohenadel et al., 2011), and by the participants of this study.

5.7 Conclusion

The systematic review revealed that the challenges and facilitators of OE research in the UK are not commonly discussed in the literature. Therefore, these issues were explored by interviewing key researchers and surveying the wider community. The interview phase participants reported the key challenges to conducting OE research in the UK including; lack of funding, difficulty accessing data and participants, lack of expertise, records issues, recruitment difficulties, and publication issues. Additionally, they identified; the facilitators, strategies they have employed to overcome some of the challenges, and recommendations to improve carrying out this type of research in the UK. These issues were tested in a subsequent quantitative phase by utilising a specifically designed questionnaire; using data from the SR and the interview phase findings. The participants of the survey phase confirmed the issues reported by the key researchers with some variations in the emphasis of the challenges. The key concerns are the lack of human and financial resources and the increasing challenges that threaten this field sustainability and development.

Further research is required to explore how the challenges were established and to identify the factors that contributed to their development. Thus, the next phase of the study will explore these issues through assessment of the contribution of OE to cancer field compared to the contribution of public health epidemiology over time, and to identify time periods and particular issues that merit further exploration in the final phase of the study by utilising a documentary analysis method.

6 TRENDS IN THE DEVELOPMENT OF OCCUPATIONAL EPIDEMIOLOGY RELATIVE TO PUBLIC HEALTH EPIDEMIOLOGY

6.1 Introduction

Overall, the findings of the previous phases revealed that OE is currently facing many challenges. Amongst those challenges, the lack of human and financial resources is of utmost importance. More importantly, the challenges are perceived to have increased over the years. Furthermore, participants believed that epidemiological studies in other health research areas and randomised controlled trials, to be more sustainable, innovative and successful than OE. These fields are believed to be better resourced because they are, according to OE researchers, more innovative and employ ‘cutting edge methodologies and techniques’, thus attracting more funds and young researchers.

Consequently, the OE community was perceived to be getting smaller, becoming more scattered and therefore becoming less powerful and influential over time. This is despite the fact that each year an estimated 1.2 million workers are still suffering from illnesses caused or made worse by their work (HSE, 2014). Furthermore, these challenges were believed to have affected the capability and capacity of OE community members to carry out research projects, thus negatively impacting the quality and quantity of studies in this field in a vicious circle.

It was not clear whether the issues discussed above are a true reflection of the current situation, or whether they were merely a perception of OE researchers interviewed and surveyed. Moreover, it was not sufficiently clear when, how, and why these recent challenges have occurred, their implications for OE, and whether these are experienced in

other epidemiological fields. Thus, these issues require both further exploration and confirmation using different approaches.

The decision then was made to evaluate UK OE field productivity and influence over time and to identify any time periods of low or high productivity that could be investigated further to understand how the challenges and the facilitators evolved. It was necessary, though, to compare OE with another similar field to be able to identify the issues that facilitated or hindered its development in comparison to this comparable field. The issues of interest also were excluded general issues which would be expected to affect similar discipline equally such as ethics and governance approvals issues. Public Health Epidemiology (PHE) was chosen as the bench mark for the comparative study, because it employs similar methodologies and techniques to the OE field, and it has a long history of establishment and operation (Schwartz, Susser, & Susser, 1999). Given the respective sizes of these fields, a specific exemplar, cancer epidemiology, was chosen for both OE and PHE to focus the study, and provide more in-depth assessment and analysis. Cancer epidemiology has been a well-established topic within both OE and PHE fields (Glynn, Chin, Kerin, & Sweeney, 2010); thus good coverage of data was anticipated.

One possible approach to address the issues discussed above is by choosing certain case studies (e.g., specific teams, research groups, or researchers) or interviewing key older researchers from OE and PHE, who started their career 20-30 years ago. However, the previous phases of this programme showed that key OE researchers are few, and many of them had already been interviewed or surveyed, thus, little additional insight could be gained from this approach. Furthermore, these methods (i.e., qualitative methods) may generate rich descriptive data. It might be difficult to generalise their findings and they run the risk of perceived as being anecdotal and subjective (Bryman, 2012). On the other hand recall bias may mean that key researchers either overestimate or underestimate the influence of certain issues under discussion, particularly if there is a long gap between the events of interest and the interview.

The method needed for this study should be suitable for a retrospective analysis that involved tracking forwards from specific time point until this current time. In the light of these considerations bibliometric analysis was chosen as the method for this study. Whilst the use of this approach may not facilitate in-depth exploration of the contextual factors (e.g. social, organisational and political), it provides a systematic and verifiable method of evaluating OE and PHE contributions to cancer epidemiology and thus allowing the

identifications of any differences and similarities that could be relevant to certain challenges and facilitators.

6.2 Aims and objectives of the bibliometric study

This phase of the study consists primarily of a systematic bibliometric investigation aimed to (i) analyse the characteristics of the OE literature over a defined period of time and compare it with the PHE literature, in the field of cancer epidemiology; (ii) identify any emerging patterns or trends in both fields and explore the likely reasons for differences that might emerge from the data; and (iii) identify any external social, economic and political factors that could explain the trends and the difference in the trends between OE and PHE fields.

The specific objectives of this bibliometric study were to:

- quantify and compare OE and PHE research outputs over time, in the field of cancer, and identify temporal evolution of scientific productivity (i.e., time points where low or high levels of publications are identified);
- explore other publication trends; for example number of authors and quality of publications (i.e. article citation scores and Journal impact factors);
- identify possible factors contributing to the variations in publication trends including research collaborations and funding;
- Identify time periods characterised by key differences in publication trends between OE and PHE, and consider the key external factors that could have influenced these differences.

The following list of questions will be answered during this study and will be used as an indicator of accomplishing the above objectives. Each question addresses a certain issue with regards to OE studies in comparison to that of the PHE field:

- How many studies (OE vs PHE) have been published in the field of cancer research?
- Which field (OE vs PHE) has produced the largest number of high impact studies, if any?
- What is the total number of new authors per year who have published new findings in each field (OE vs PHE), and what are their characteristics, for example number of publications and citations?
- Which field (OE vs PHE) has the highest levels of national and international collaborations?

- What are the characteristics of the leading (or top) journals in which each field has published its key articles?
- What are the characteristics of the top organisations that produced the highest number of publications in each field?
- How many studies in OE employed molecular and genetic techniques over the years compared to those within PHE?
- What are the types of clinical conditions investigated in OE studies compared to PHE studies?

6.3 Methods

In the following section the terminology and tools of bibliometric analysis are discussed first followed by a description of the adopted methodology for database search and data extraction, management and organisation.

6.3.1 Bibliometric analysis

The term bibliometric was first introduced by Pritchard in 1969 to indicate a new discipline which employed quantitative methods for analysing various aspects of scientific publications to assess the patterns and dynamics in these publications (Pritchard, 1969). Bibliometrics can be applied to the identification of articles on particular topics in order to measure their relative size within the scientific literature (Falagas, Pitsouni, Malietzis, & Pappas, 2008; Pritchard, 1969; Ramos, González-Alcaide, & Bolaños-Pizarro, 2013). This type of investigation also evaluates the scholarly outputs of citations, authors, institutions, and countries, and identifies the temporal evolution of research patterns (Karageorgopoulos, Lamnatou, Sardi, Gkegkes, & Falagas, 2011; Ramos et al., 2013). It is possible then to illustrate the association between scholarly works and the nature of development in a given research field (Borgman & Furner, 2002); for example; whether there is a relationship between authors or their affiliations and the quality of research studies.

Given the descriptive nature of this study, a bibliometric analysis therefore offered an ideal method for certain indications to relevant OE and PHE challenges and facilitators over time, and allowed for the identification of key time points that merited further investigation in a subsequent phase of the study.

6.3.2 Bibliometric analyses tools

A range of standard bibliometric tools were used in this study, including: counts of papers, citation analysis, percentage of cited papers, authorship analysis and collaboration indicator. Each of these tools is discussed briefly below.

- *Counts of papers*

Paper counts measure productivity and provide the raw data for all citation analyses. Each field and its associated organisations were ranked, in terms of paper counts, to compare the productivity and volume of research output among both fields and various organisations. The publication growth rate was also calculated for both fields. The formula used to estimate the growth rate of OE or PHE publications is:

$$\text{Annual growth rate} = \frac{\text{Current year total paper count} - \text{Previous year total paper count}}{\text{Previous year total paper count}}$$

Citation analysis

Citation analysis is generally regarded as a valuable tool for assessing the impact and performance of scientific research output in certain disciplines of interest (Merton, 1988). Citations represent the association of scientific ideas, and the references which authors cite in their papers make explicit the link between their current research and prior work in the scientific literature archive (Andres, 2009). Therefore, the analysis of publication data can help quantify the performance and impact of a given set of publications produced by an individual/organisation within the OE and the PHE. To perform a citation analysis, the citation count of the included studies was extracted from the ISI-Thomson Web of Science (WoS, previously known as Web of Knowledge) platform. WoS is the leading source for bibliometric citation databases which has been produced by Thomson Scientific. The WoS provides citation analysis of all indexed articles since 1946.

Percentage of cited or un-cited papers

To measure the number of publications that have no or very little influence, the percentage of cited or un-cited papers in both fields was calculated.

Authorship analysis

Examination of trends in authorship was performed including the percentage of articles written by a single author and the mean number of authors per article. Identification and tabulation of the characteristics of individuals with the highest publication rates was also carried out. This included any number of publications produced from the same study such as cohort studies.

Collaboration indicators

The multiple-author publication, frequently referred to as a co-authored publication, has been used as a basic counting unit to measure collaborative activity (Andres, 2009; Glanzel, 2003). Metrics for collaboration include rates of co-authorship for pairs of authors, and institutions. They can include standard series such as the percentage of papers with 1, 2, 3, etc. authors over time, as well as the calculation of impact for each field and its institutional collaboration pairs. Co-authorship analysis is employed to present some characteristics of trends in co-authorship patterns for OE and PHE publications, and whether any of the identified characteristics has an effect on the publication trend of any of the fields.

6.3.3 Search strategy and study selection

A search strategy was developed to identify primary studies indexed in relevant databases or included in key research journals. A selection (and exclusion) criteria of studies was developed and hence the obtained full-text articles from each search were independently and thoroughly reviewed and checked on whether they meet the eligibility criteria before being included for the next stage of data extraction and analysis.

6.3.3.1 Eligibility Criteria

The following list of inclusion criteria of potentially eligible studies were based on the specific research questions set out early in this phase of the thesis:

- Studies published from 01/01/1965 to 31/12/2012 (the search was conducted in 2013). Research on cancer epidemiology discipline grew rapidly after 1960s.
- Studies aimed to examine the occurrence, causes, and prevention of cancer and pre-neoplastic diseases, at a community or population level, and whose methodology clearly presents an epidemiological study design and have the following two criteria:
 - studies that examined frequency or patterns of risk factors and how these may be related to disease at a community or population level
 - studies that investigated whether or not a causal relationship exists between exposure to a risk factor and subsequent illness, disease or health outcome of public health significance
- Study reports of UK-based research, because the study is focussing on the UK context only. Nonetheless, multi-centre international studies are included if one of the collaborating centres -that carried out research activities- is located in the UK.
- Research reports only.

6.3.3.2 Exclusion criteria:

- Letters to editor, commentaries, conference papers, letters, notes, meta-analysis and reviews.
- Articles lacking a clear definition of the research question, and those for which the design has been presented inadequately.
- Clinical epidemiology studies that focus on patient population (e.g., risk factors in patient populations)
- Experimental studies including RCTs assessing the efficacy and effectiveness of cancer treatments.
- Methodological studies focusing on research methods or analytical techniques.
- Studies that employed data (or part of the data) from the UK; yet the study author/s are not UK-based authors and/or did not participate in the data collection for the studies.
- Non-English language studies, because it is unlikely that the study has been carried out in the UK or exploited data from the UK.
- Studies that aimed at screening Animal studies

6.3.4 Methodology for identifying eligible studies

Two pilot studies were initially conducted before deciding on the appropriate method to identify eligible studies to be included in the analysis: key journal search and database search.

6.3.4.1 Key journals search

In the first pilot study, five key research journals were selected for the purpose of bibliometric assessment in this study. These five journals are well-established in the UK, are widely read, and are of general interest to researchers in the various fields of epidemiology. The journals were chosen on the basis that they are either academic field-specific journals or prominent cross-disciplinary journals; thus addressing a broad spectrum of issues under investigation (i.e., OE and PHE cancer epidemiology studies) from both general and specific prospects. The selected journals represent OE, PHE, general medicine and cancer fields:

- British Medical Journal (BMJ)
- Occupational Medicine (OM)
- OM and Occupational and Environmental Medicine (OEM)
- Journal of Epidemiology and Community Health
- British Journal of Cancer

The adopted approach was to screen every second issue of the year biannually until the year 2012. For the pilot study, an issue of each journal was screened for eligible studies during the following years: 1961, 1971, 1981, 1991, 2001, and 2011. A total of 188 studies were found, from those there were only nine eligible PHE studies compared to a single OE study. Therefore, the number of studies this approach could yield would not be sufficient to provide enough data for further bibliometric analysis. Additionally, the eligible studies found were concentrated in two years (1961 and 1981) and no eligible studies were found during 1971 (Table 6-1). Thus, it was concluded that this approach is not appropriate to establishing representative trends of both fields' publications.

Table 6-1: Eligible articles found in five journals and whether they were retrieved by the database search strategy

Title of article	Publication Year	Eligibility	Found in database search
Tumours in children. A survey carried out in the Manchester region.	1961	Yes	No
Cancer of the lung in South-West England and London: an epidemiological study of histological type.	1961	Yes	No
Gastro-intestinal Cancer and Geochemistry in North Montgomeryshire.	1961	Yes	No
The Cardiff Cervical Cytology Study. Prevalence and epidemiology of cervical neoplasia.	1981	Yes	Yes
A case-control study to investigate the association between exposure to benzene and deaths from leukaemia in oil refinery workers.	1981	Yes	Yes
Childhood leukaemia in North West England 1954-1977: epidemiology, incidence and survival.	1981	Yes	Yes
Malignant disease in the mothers of a population-based series of young adults with bone and soft tissue sarcomas.	1991	Yes	Yes
Case-control study of leukaemia and non-Hodgkin's lymphoma in children in Caithness near the Dounreay nuclear installation.	1991	Yes	Yes
Parental occupations of children with leukaemia in west Cumbria, north Humberside, and Gateshead.	1991	Yes	Yes
Early life exposure to diagnostic radiation and ultrasound scans and risk of childhood cancer: case-control study.	2011	Yes	Yes

6.3.4.2 Bibliographic database search

As the approach of searching key-journals was not successful, it was decided to test another approach that employs a comprehensive and multi-disciplinary bibliographic database. This was to allow extraction of a large number of potentially eligible articles published in both

OE and PHE fields, rather than collecting a random sample from a small number of journals. The next step was to decide on the most appropriate bibliographic database and the search strategy to be employed.

Considering the size of the study and the large number of eligible articles expected to be found, one key database was considered sufficient. MEDLINE ('National Library of Medicine-National Institutes of Health', 2014) was used to conduct a bibliometric evaluation of articles published in the fields of OE and PHE. This large database (> 22 million references to journal articles) for medical literature uses strict principles for the selection of journals, based on scientific quality and importance ('National Library of Medicine-National Institutes of Health', 2014). MEDLINE is regarded as the best and most comprehensive available database in terms of covering English language medical literature covered from 1946 to the present (Falagas et al., 2008). Scopus includes a wider range of journals than MEDLINE and Web of Science; nevertheless, its citation tracking is currently limited to articles published after 1995; thus it was not suitable for this study.

Furthermore, MEDLINE have a collection of unique features that can facilitate bibliometric analysis including a controlled vocabulary, the Medical Subject Headings (MeSH) thesaurus, a hierarchical structure made up of 27,149 descriptors and over 218,000 entry terms (<http://www.nlm.nih.gov/pubs/factsheets/mesh.html>; accessed August 2014). The MeSH was developed by the National Library of Medicine (NLM) over 50 years, and is continually revised and updated by subject specialists. Each bibliographic reference is associated with a set of MeSH terms that describe the content of the item. Similarly, search queries use MeSH vocabulary to find items on a desired topic, which help to perform accurate searches.

The MEDLINE database can be found on many different search platforms including; EBSCOhost, Web of Knowledge, Ovid, and PubMed. The MEDLINE database was searched for eligible articles in two different search platforms; Web of Knowledge (WOK; as of Jan 2014 named Web of Science) and EBSCO. Initially the search was conducted in EBSCO. Then, for the purpose of testing and verification of the results, the same search was performed again in the WOK platform yielding more eligible articles which indicates that WOK has more comprehensive coverage of scientific literature. The search was carried out in March-April 2013 and covered the publication period from 1965 to 2012.

Developing a database search strategy was an iterative process in which the used terms were modified, based on what had already been retrieved. Initially, keywords search approach was developed based on three key terms; cancer, epidemiology and UK. An example of a built keywords search approach that uses Boolean operators (i.e., OR and AND) to refine search results is given below:

TX ((epidemiolog OR "case control" OR cohort OR "case referent" OR registry OR "cross sectional" OR prevalen* OR inciden* OR survey) AND (cancer* OR neoplas* OR carcinogen* OR malignan* OR tumo?r* OR adenoma* OR carcinoma* OR adenocarcinoma* OR sarcoma* OR precancer* OR preneoplast* OR lesion* OR cyst* OR lymphoma* OR leuk?emia*)) AND TX (UK OR United Kingdom OR U.K OR Britain OR England OR Wales OR Scotland OR Ireland)*

This search yielded unmanageable search result of 125,348 publication records (Limiters - Date of Publication from: 19510101-20111231; English Language). Additionally, the search lacked precision as it produced a vast number of irrelevant records. Furthermore, it was not possible to be sure that all relevant terms to retrieve eligible articles were used. For example, all types of cancers and their related terms (e.g., mesothelioma and neuroblastoma) are vast, thus capturing these in a single search is difficult. Hence, keywords search approach was considered inappropriate for this study.

After consultation with a systematic reviews search strategy building expert (Dr Beverly French; The University of Central Lancashire), she advised on the use of a controlled vocabulary, the medical subject headings (MeSH) thesaurus as cores for the search strategy, which was subsequently adopted to build the search strategy (See section 5.4.3.3 below).

The developed search strategy was subsequently tested for sensitivity by assessing whether it retrieved the same eligible articles found from screening a sample of key journals (Table 6-1). It was noted that the three articles published in 1961 were not found in either the keywords or the MeSH-based searches. Articles published during this era were indexed in the OLDMEDLINE, which may explain the failure of the used database search in retrieving these articles. OLDMEDLINE represents journal article citations from two printed indexes; Cumulated Index Medicus (CIM) and the Current List of Medical Literature (CLML). OLDMEDLINE was created by the National Library of Medicine (NLM) and contain about 2,010,000 citations to articles from international biomedical journals cover the fields

of medicine, preclinical sciences and allied health sciences from 1946 through 1965 ('OLDMEDLINE Data', n.d.).

OLDMEDLINE citations reflect the contents of the original printed indexes that were produced under policy and procedures of the time. Citations lack the individual and accumulated changes and improvements that have been made to data in other NLM files during annual file maintenance. Certain fields may contain outdated or erroneous data and the data are not typographically consistent from year to year. OLDMEDLINE records also lack abstracts, which means that keyword or text-word searches are only searching the title field of the reference. Additionally original subject headings have not been updated, and may not match current MeSH vocabulary. Furthermore, it was noted that only 19 eligible publications were found in MEDLINE during the period 1950–1964, after this period, there was a remarkable increase of records. As a result, the decision was to limit the search from the year 1965 onwards.

6.3.5 Search filter

A complex search strategy was formulated using primarily MeSH and keywords to retrieve references (detailed steps of the electronic database search process are outlined in Appendix C-1. The filter was built using three main MeSH terms groups, which were exploded in MEDLINE (explosion is a tool that automatically searches the MeSH term (e.g., neoplasms, epidemiology) as well as the more specific terms underneath that term in the MeSH hierarchy, for example, the specific types of cancer or epidemiological studies):

- the first MeSH term is neoplasms(neoplasms[mesh]),
- the second is epidemiology; including all relevant MeSH (i.e., (MH "Epidemiology+") (MH "Epidemiologic Factors+"), (MH "Epidemiologic Methods+"), (MH "Epidemiologic Studies+"), and (MH "Epidemiologic Measurements+")),
- the third is UK (i.e., (MH "Great Britain+")). Additional free text was added for this term because it was found during the pilot stage that MeSH term alone does not retrieve all UK articles.

Finally, the exclusion tool in MEDLINE was used to exclude reviews, conferences proceedings, clinical studies and other irrelevant studies (Appendix C-1). The MEDLINE database can be found on many different search platforms including; EBSCOHost, Web of Knowledge, Ovid, and PubMed. The MEDLINE database was searched for eligible articles in two different search platforms; Web of Knowledge (WOK) and EBSCO. Initially the

search was conducted in EBSCO. Then, for the purpose of testing and verification of the results, the same search was performed in the WOK platform. Searching MEDLINE in two platforms yielded more eligible articles. The search was carried out in March-April 2013, and covered the period 1965-2012.

6.3.6 Data extraction, management and organisation

6.3.6.1 Articles extraction

Inclusion and exclusion criteria were applied to titles and abstracts, and then to full-texts. The full-texts were obtained for those studies that appeared to meet the inclusion criteria or where there was insufficient information to be sure. The inclusion and exclusion criteria were then re-applied to the full-texts, and those that did not meet these initial criteria or met any of the exclusion criteria were excluded from the final analysis.

The articles retrieved were then independently reviewed before classifying them as an OE or PHE study of cancer. Studies that their primary research questions were focusing on work-place exposure and on a working population were classified as OE studies; otherwise, they were classified as PHE. Any uncertainty regarding inclusion was discussed with the supervisory team.

6.3.6.2 Data extracting from eligible articles

Manual extraction of data from hundreds of eligible articles was very time consuming, therefore, the HistCite software was used to try speed up and facilitate this process. HistCite is software designed by Thomson Reuters to help visualize the results of literature retrieved from the Web of Science (WoS) ('Guide to HistCite reports', n.d.), which was used to streamline the data extraction and analysis process. Once a search is performed in the WoS, a 'marked lists' can be created by choosing the relevant references. The resulting marked lists can be downloaded in the WoS EXPORT format, which is a plain ASCII text. This plain ASCII text file can be then processed by the HistCite program.

Additionally, the HistCite software allows citation analysis of articles that are directly downloaded from WoS. In WoS, however, it is not possible to perform a MeSH terms search, and only keyword searches are possible. Therefore, after extracting eligible articles from MEDLINE in WOK and EBSCOHost, a manual search for each article in the WoS was performed. Each article was then added to the "Marked lists" and downloaded as a plain text format file ready to be analysed by HistCite. Articles in the marked list cannot be saved; thus, whatever number of articles I was able to process in a session has to be downloaded and saved as plain text file immediately before logging out of the WoS

database. The resulting Export files were processed by HistCite to create tables ordered by author, year, or citation frequency (Figure 6-1) as well as historiographs, which include a small percentage of the most-cited papers and their citation links.

The screenshot shows the HistCite™ interface for an 'Untitled Collection'. It displays a list of 10 records with various citation metrics. The interface includes a menu bar (File, Analyses, View, Tools, Help) and a status bar with summary statistics: Grand Totals: LCS 1908, LCSx 1057, GCS 55498, OCS n/a, CR 34241, NA 10942; Means: LCS 1.43, LCSx 0.79, GCS 41.63, OCS n/a, CR 25.69, NA 8.21; Collection span: 1965 - 2012 (48 years).

#	Date / Author / Journal	LCS	LCS/t	LCSx	GCS	GCS/t	OCS	NA	LCR	CR	LCSb	LCSe	LCS (e/b)
1965													
1	DEAN G LUNG CANCER IN CHANNEL ISLANDS BRITISH JOURNAL OF CANCER. 1965 1965; 19 (4): 661-8	0	0.00	0	3	0.06		1	0	0	0	0	0
2	RICHARDS,IM PROSTATIC CANCER AND SOCIAL CLASS BRITISH JOURNAL OF PREVENTIVE & SOCIAL MEDICINE. 1965 1965; 19 (3): 140-8	1	0.02	1	18	0.38		1	0	0	0	0	0
3	LEA AJ NEW OBSERVATIONS ON DISTRIBUTION OF NEOPLASMS FEMALE BREAST IN CERTAIN EUROPEAN COUNTRIES BRITISH MEDICAL JOURNAL. 1965 1965; 1 (5433): 488-8	0	0.00	0	9	0.19		1	0	0	0	0	0
4	ADAMS MJT, SPICER CC RECENT MORTALITY FROM BREAST CANCER LANCET. 1965 1965; 2 (7415): 732-8	1	0.02	1	12	0.25		2	0	0	0	0	0
5	CASE RAM MORTALITY FROM CANCERS OF CHILDHOOD PROCEEDINGS OF THE ROYAL SOCIETY OF MEDICINE-LONDON. 1965 1965; 58 (8): 607-8	0	0.00	0	2	0.04		1	0	0	0	0	0
6	MANDERSON W G, PATRICK R S, PETERS E E PRIMARY CARCINOMA OF LIVER; A SURVEY OF CASES ADMITTED TO GLASGOW ROYAL INFIRMARY DURING 1949-1963. SCOTTISH MEDICAL JOURNAL. 1965 1965-Feb; 10: 60-4	0	0.00	0	10	0.21		3	0	0	0	0	0
1966													
7	AITKENSW J, BAIRD D CANCER OF UTERINE CERVIX IN ABERDEENSHIRE - EPIDEMIOLOGICAL ASPECTS BRITISH JOURNAL OF CANCER. 1966 1966; 20 (4): 624-8	0	0.00	0	21	0.45		2	0	0	0	0	0
8	ASHLEY DJB, DAVIES HD GASTRIC CANCER IN WALES GUT. 1966 1966; 7 (5): 542-8	0	0.00	0	18	0.38		2	0	0	0	0	0
9	SPRINGET,VH BEGINNING OF END OF INCREASE IN MORTALITY FROM CARCINOMA OF LUNG THORAX. 1966 1966; 21 (2): 132-8	0	0.00	0	25	0.53		1	0	0	0	0	0
1967													
10	ASHLEY DJB DISTRIBUTION OF LUNG CANCER AND BRONCHITIS IN ENGLAND AND WALES BRITISH JOURNAL OF CANCER. 1967 1967; 21 (2): 243-8	0	0.00	0	26	0.57		1	0	0	0	0	0

Figure 6-1: A screenshot of data analysis using HistCite.

Additionally, a database was created in Microsoft Excel that includes all records by using HistCite. The database includes: titles, authors, number of authors per article, year of publication, authors' institutions, departments, groups and countries, and citation frequencies. The database was used to perform further in depth analysis of the bibliographic data and to allow for data sorting and filtration; for instance, topics of the studies, authorship, institution and journal impact factors analyses. The impact factors (IFs) of all journals were evaluated using the Journal Citation Report (JCR; Web of Knowledge) 2013 science edition by Thomson Reuters (New York, NY, USA). The IFs of the retrieved journals were collected for the available years 1997-2013 for the top 10 journals in each field.

6.3.7 Data analysis

Data from HistCite and JCR were exported to Excel for analysis and descriptive statistics were used in data presentation. Descriptive statistics was used as it helps identifying the main characteristics of the data, assists summarising the main features of the data set, and permits identification and presentation of the relationships between two or more variables within the data in a coherent manner (Polit & Beck, 2006). Discrete data are presented as means, and categorical data are expressed as numbers with percentages.

Time-series plots were used, which provided insight into the change in research output and impact over time. Furthermore, data was analysed graphically using scatterplots and histograms that provided visual summaries of data.

Correlation analyses results were presented to assess whether relationships existed between certain variables. Differences were considered statistically significant if *p-value* (two-tailed) ≤ 0.05 (Bowling & Ebrahim, 2005).

6.4 Results

This section presents results from bibliographic database search and bibliometric analysis.

6.4.1 Bibliographic database search results

A total of 27,696 references were identified through electronic searches of MEDLINE in WOK ($n = 13518$), and EBSCO ($n = 14178$). In total, 6971 duplicate references were excluded; 6879 of them by using EndNote X5 and 92 were excluded manually. Another 19144 articles were clearly irrelevant and were excluded through screening titles ($n = 17970$), abstracts ($n = 903$), and full-texts ($n = 208$). Furthermore, there were 17 articles that did not have abstracts, and it was not possible to obtain their full-text so that to examine their eligibility, and thus they were excluded from the analysis. Thus, the final number of eligible references was 1627 (OE = 294 and PHE = 1333) which has been subjected to the final phase of analysis. This refinement procedure is summarised in Figure 6-2.

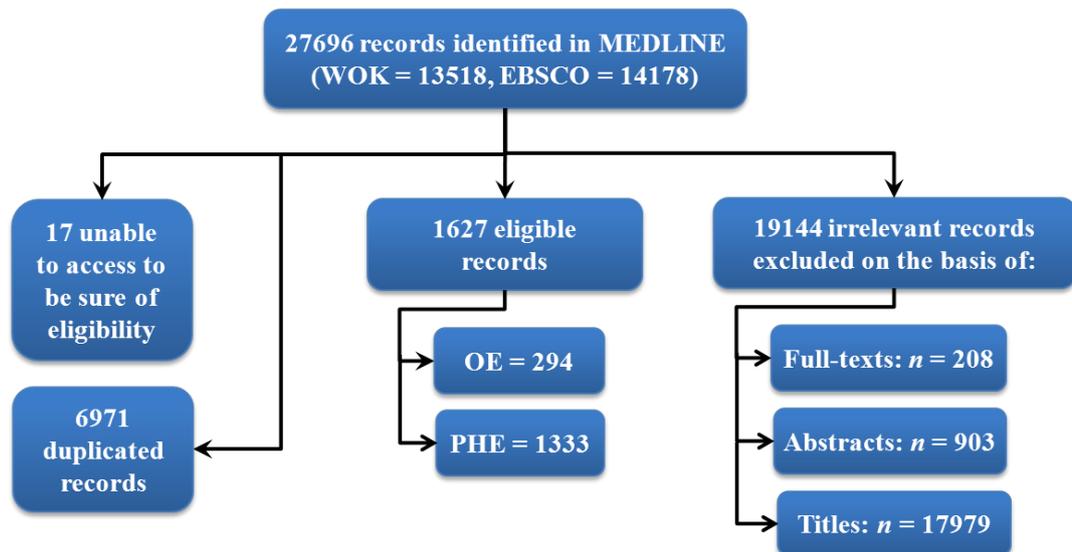


Figure 6-2: A flow-chart illustrating the procedure employed in the refinement of bibliometric search results.

6.4.2 Bibliometric analysis results

In the following sections, the results of the bibliometric study are presented. The results are only relevant to cancer studies in the fields of PHE and OE. Thus, when referring to PHE or OE field in the result sections, the findings are primarily applicable to cancer studies but may not necessarily be applicable to other areas in either of the two fields (e.g., musculoskeletal, respiratory or infectious diseases).

6.4.2.1 Publication trends

There was a total of 1627 articles on cancer epidemiology in MEDLINE during the period from 1965 to 2012, of which, 1333 (82%) articles were in the field of PHE and the remaining 294 (18%) articles were belonging to the OE field.

Temporal trends of the number of published PHE and OE articles are shown in Figure 6-3. Comparing the 65 published PHE articles in 2012 to the 6 articles published in 1965 shows an increase of approximately 11-fold. However, for the OE data there was hardly any visible increase in publication records from 1965 (5 articles) to 2012 (6 articles).

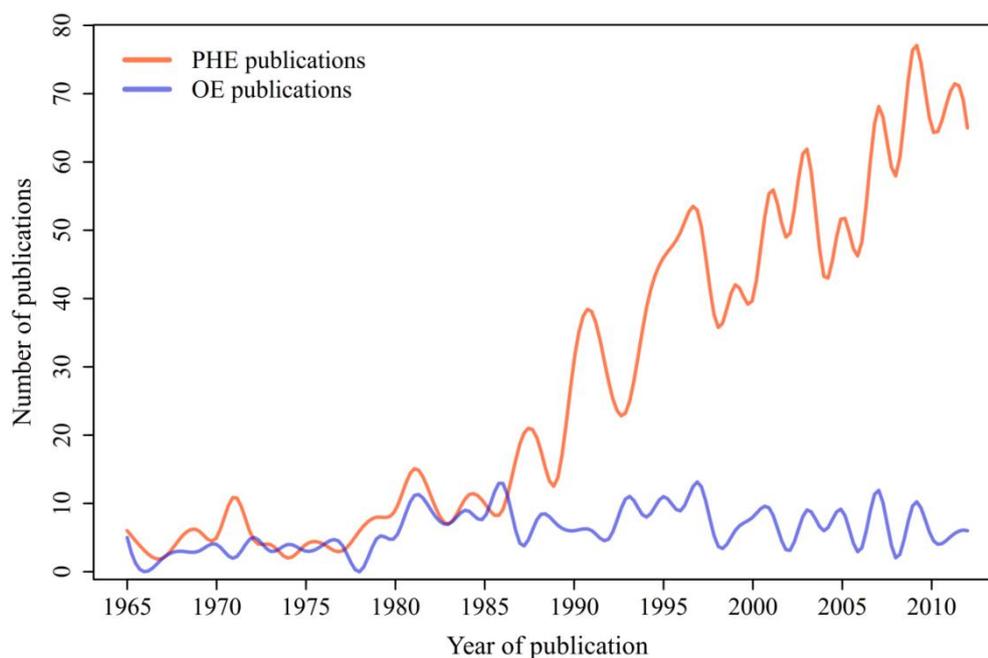


Figure 6-3: Temporal trends in OE publications versus PHE publications in the period from 1965 to 2012.

6.4.2.2 Publication growth

The data presented in Figure 6-3 show that there is a trend, almost exponential, toward growth of the PHE publication counts whereas the rate of increase of the OE publication counts remains largely unchanged over time. Interestingly, there is a noticeable acceleration

of PHE publications around 1985, which continues to grow at similar rate despite temporary decreases at several points in time.

The average number of publications per year for PHE is 26.8 which is about 4 times higher than that for OE (6.1 per year). From 1965 until 2012, the average growth rate of OE publications was 6.3%, with a doubling time of 16.6 years. For PHE publications, the average growth rate is 8.6%, with a doubling time of 7.8 years. In view of that, we can expect the OE publications of 6 in 2012, to become 12 records by 2028, and the average PHE publications of 65, in 2012, to become 130 in 2019, if the current growth continues.

6.4.2.3 Citation analysis

In total, the 294 OE articles published since 1965 were cited 11033 times whereas the 1333 PHE articles published since 1965 were cited 55498 times. The average citation per paper was 37.5 for OE, and 41.6 for PHE studies (Figure 6-4). Thus, the average citation per year was 229.8 for OE papers compared to 1156.2 for PHE papers.

PHE articles published between 1995 and 2005 were cited more than those articles published before 1995 or after 2005. OE articles published before 1995 tend to be cited more than those published after 1995.

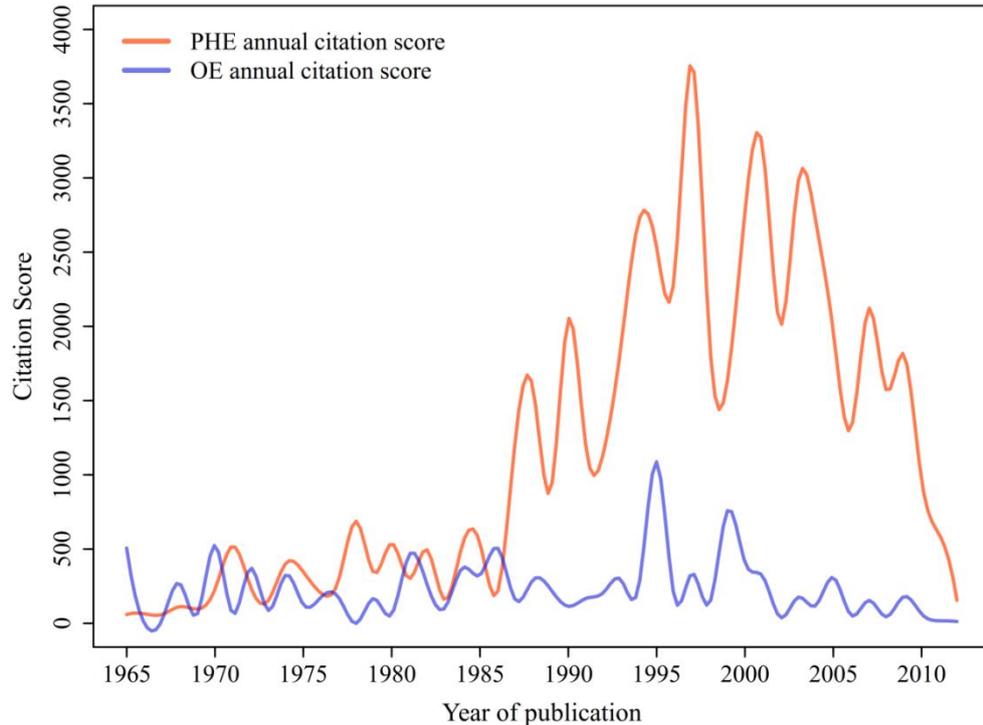


Figure 6-4: Temporal citation trends of OE and PHE studies during the period 1965-2012.

Figure 6-5 illustrates that there is a positive correlation between the number of articles published each year and the number of citations both in OE (Pearson correlation (r) = 0.61, p -value < 0.001) and PHE (r = 0.75, p -value < 0.001). In other words, the number of citations that a field receives in a given year increases as the number of published articles increases.

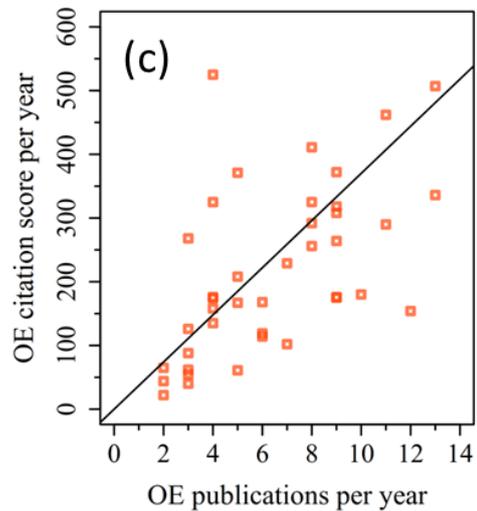
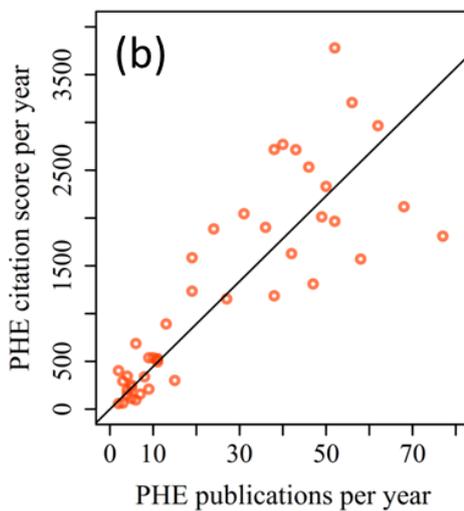
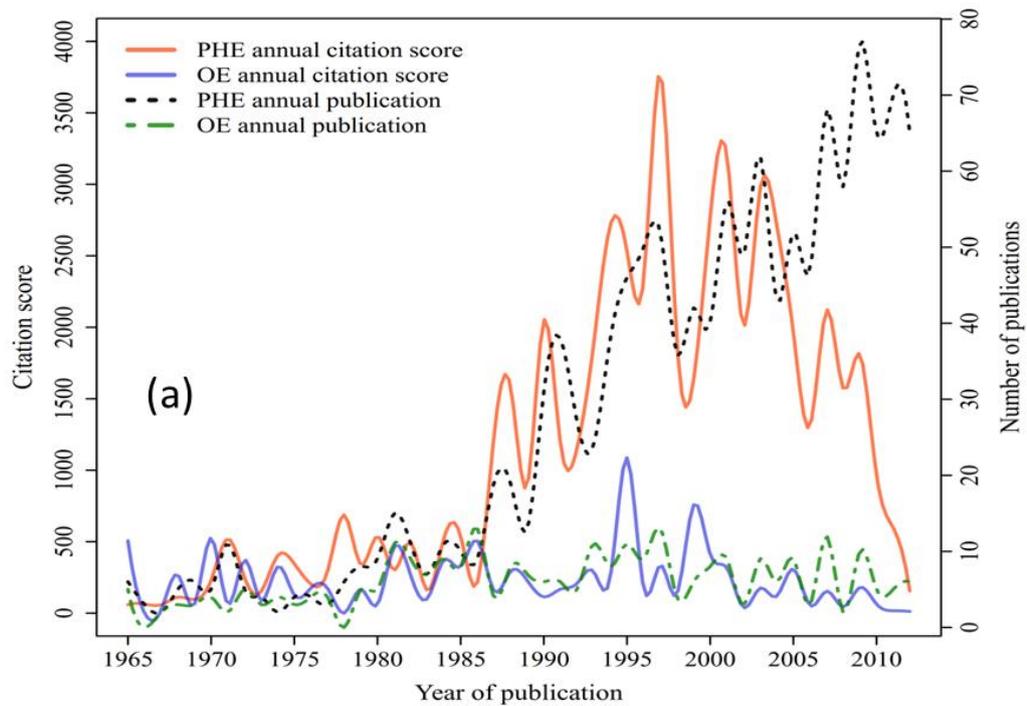


Figure 6-5: (a) OE & PHE publications and citation trends versus publication year (b) number of PHE publication vs number of citations per year (c) number of OE publication vs number of citations per year. The solid lines in (b) and (c) represent linear regression fitted to data.

6.4.2.4 Cited/un-cited articles

A total of 280 (95.2%) articles were cited at least once in the field of OE, and 14 (4.8%) articles were not cited. Similar pattern is observed in the PHE field where 1286 (96.5%) articles were cited once or more and 47 (3.5%) articles received no citations.

6.4.2.5 The use of molecular and genetic techniques (new methods)

The number of studies that utilised molecular and genetic techniques in PHE is 339 (25.4%), (Figure 6-6); however, in OE only 8 (2.7%) studies were found (published in 1967, 1968, 1973, 1974, 1975, 1980 1995, and 2001).

Figure 6-6 demonstrates the positive impact of genetic techniques employed in PHE studies on the growth of the field in comparison to molecular techniques employed during the same period from 1990 to 2012.

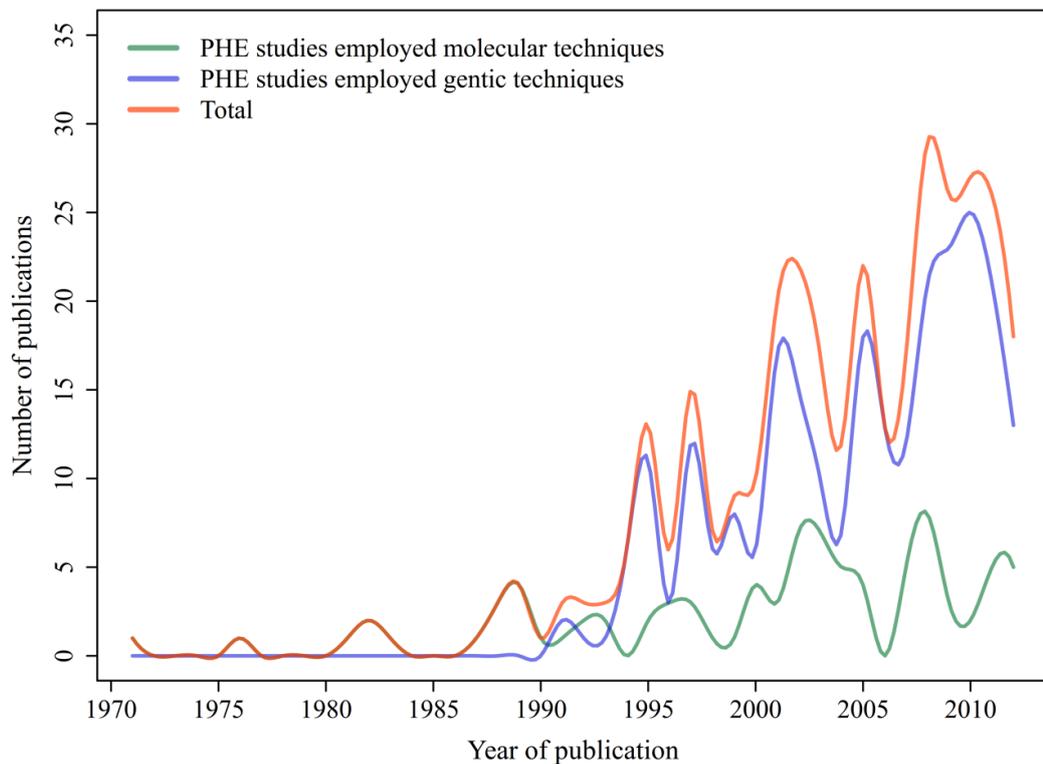


Figure 6-6: The impact of the application of genetic- and molecular-based techniques on the number of publications and growth of the PHE field.

6.4.2.6 Top research topics

The top three research topics within the 1333 PHE studies were: breast cancer ($n = 176$, 13.2%), cancer in general ($n = 176$, 13.2%), and childhood malignancies ($n = 138$, 10.4%). Whilst within the 294 OE studies, the top three research topics were: cancer mortality

($n=87$, 29.6%), lung related malignancies (including asbestosis and mesothelioma) ($n = 86$, 26.3%), and cancer in general ($n = 39$, 13.3 %).

6.4.2.7 Highly cited articles

Citation scores for the 20 most cited studies is much higher in PHE, ranging from 297-1154 (mean = 490), than in OE, ranging from 98-500 (mean = 187) (see Tables 6-2 & 6-3).

The top 20 highly cited articles were published between 1978 and 2004 in PHE; but the majority of these were published during 1990s ($n = 11$) and 2000s ($n = 7$). In OE, the 20 most cited articles were published between 1965 and 2005; however, half of these were published during 1965 and 1986 ($n = 10$). Seven out of the 20 most cited PHE articles employed genetic and molecular techniques in comparison with only three OE studies employing similar techniques.

Table 6-2: Top 20 most cited PHE articles published during the period 1978 – 2004.

Authors	Title of Article	Total citation	Year
Ford et al.	Risks of cancer in brca1-mutation carriers	1154	1994
Easton et al.	Genetic-linkage analysis in familial breast and ovarian-cancer - results from 214 families	1046	1993
Doll et al.	Mortality in relation to smoking: 50 years' observations on male British doctors	811	2004
Calle et al.	Breast cancer and hormonal contraceptives: Collaborative reanalysis of individual data on 53297 women with breast cancer and 100239 women without breast cancer from 54 epidemiological studies	624	1996
Peto R. et al.	Smoking, smoking cessation, and lung cancer in the UK since 1950: combination of national statistics with two case-control studies	552	2000
Gardner et al.	Results of case-control study of leukemia and lymphoma among young-people near sellafield nuclear-plant in West Cumbria	529	1990
Doll & Peto R.	Cigarette-smoking and bronchial-carcinoma - dose and time relationships among regular smokers and lifelong non-smokers	453	1978
El-Omar et al.	Increased risk of noncardia gastric cancer associated with proinflammatory cytokine gene polymorphisms	436	2003
Bingham et al.	Dietary fibre in food and protection against colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC): an observational study	415	2003

Woodman et al.	Natural history of cervical human papillomavirus infection in young women: a longitudinal cohort study	413	2001
Dunlop et al.	Cancer risk associated with germline DNA mismatch repair gene mutations	377	1997
Ford et al.	Estimates of the gene-frequency of brca1 and its contribution to breast and ovarian-cancer incidence	375	1995
Gayther et al.	Germline mutations of the brca1 gene in breast and ovarian-cancer families provide evidence for a genotype-phenotype correlation	375	1995
Thompson & Easton	Cancer incidence in BRCA1 mutation carriers	358	2002
Gyde et al.	Colorectal-cancer in ulcerative-colitis - a cohort study of primary referrals from 3 centers	347	1988
Black et al.	Cancer incidence and mortality in the European Union: Cancer registry data and estimates of national incidence for 1990	336	1997
Powell & Mcconkey	Increasing incidence of adenocarcinoma of the gastric cardia and adjacent sites	304	1990
Smith et al.	Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study	299	1998
Eaden et al.	Colorectal cancer prevention in ulcerative colitis: a case-control study	298	2000
Lever et al.	Do inhibitors of angiotensin-I-converting enzyme protect against risk of cancer?	297	1998

Table 6-3: Top 20 most cited OE articles published during the period 1965 – 2005.

Authors	Title of Article	Total citation	Year
Peto et al.	The european mesothelioma epidemic	500	1999
Peto et al.	Continuing increase in mesothelioma mortality in Britain	356	1995
Cardis et al.	Effects of low-doses and low-dose rates of external ionizing-radiation - cancer mortality among nuclear industry workers in 3 countries	302	1995
Newhouse &Thompson	Mesothelioma of pleura and peritoneum following exposure to asbestos in london area	290	1965
Hodgson & Darnton	The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure	240	2000

Acheson et al.	Nasal cancer in woodworkers in furniture industry	235	1968
Doll & Morgan	Cancers of lung and nasal sinuses in nickel workers	206	1970
Risch et al.	Slow n-acetylation genotype is a susceptibility factor in occupational and smoking-related bladder-cancer	193	1995
Hodgson et al.	The expected burden of mesothelioma mortality in great britain from 2002 to 2050	157	2005
Anthony & Thomas	Tumors of urinary bladder - an analysis of occupations of 1030 patients in leeds-england	149	1970
Doll et al.	Mortality of gasworkers - final report of a prospective study	134	1972
Kendall et al.	Mortality and occupational exposure to radiation - 1st analysis of the national-registry-for-radiation-workers	124	1992
Berrington et al.	100 years of observation on British radiologists: mortality from cancer and other causes 1897-1997	119	2001
Greenber & Davies	Mesothelioma register 1967-68	112	1974
Smith & Douglas	Mortality of workers at the sellafield plant of British-nuclear-fuels	110	1986
Acheson et al.	Nasal cancer in northamptonshire boot and shoe industry	107	1970
Muirhead et al.	Occupational radiation exposure and mortality: second analysis of the national registry for radiation workers	106	1999
Whitwell et al.	Study of histological cell-types of lung-cancer in workers suffering from asbestosis in united-kingdom	100	1974
Yates et al.	Malignant mesothelioma in south east England: clinicopathological experience of 272 cases	99	1997
Acheson	Nasal cancer in furniture and boot and shoe manufacturing-industries	98	1976

6.4.2.8 Authorship analysis

Unique authors in each field

The total number of unique authors, who published cancer related research, in the field of PHE, is 4133, and in the field of OE is 618. This includes all UK-based and international co-authors who published their findings from 1965 until 2012. The average number of authors per article is higher in the field of PHE (3.1 authors/article) than in the OE field (2.1 authors/article). Providing an estimate of the number of researchers in each field is a useful indicator of the community size of each field and the breadth of topics addressed. However, the total numbers mentioned above, include international authors who co-authored UK-based researchers. The next section looks at UK authors alone.

Unique UK-based authors' trend

It is possible to assess the size and growth rate of each field in the UK, by calculating the number of new researchers who enter (first entered is measured by first time an author published an article) the field each year. To undertake this assessment, a list was created containing all author names (including duplicates; PHE = 10647, OE = 723) and the year in which the author's article was published. Some authors published several articles in different years, but each was only counted once and for the earliest year of publication. For example, if A. Smith published 3 different articles in 1994, 2003, and 2008, he would be included once and for the year 1994 (i.e., the year the author first published in this field).

Out of the 618 unique OE authors, a total of 561 (90.8%) were unique UK-based researchers who entered (i.e., published the first paper in this field) the field during the study period (1970 - 2012), with an average of approximately 12 new researchers each year (Figure 6-7). The number of new researchers has fluctuated over the years without an obvious trend ($r = 0.2$, p -value < 0.001). However, the number peaked at 34 authors, in 1995, and 35 authors in 2003. The total number of international authors was 57 (9.2%).

In PHE, there were 3044 out of 4133 (73.7%) new UK-based authors during the study period, with an average of 63 authors per year (Figure 6-7). Although the number of new authors has fluctuated over time; yet, there is a trend towards growth in the number of new authors entering the field, particularly after mid-1980s ($r = 0.9$, p -value < 0.001). The total number of international authors was 1089 (26.3%).

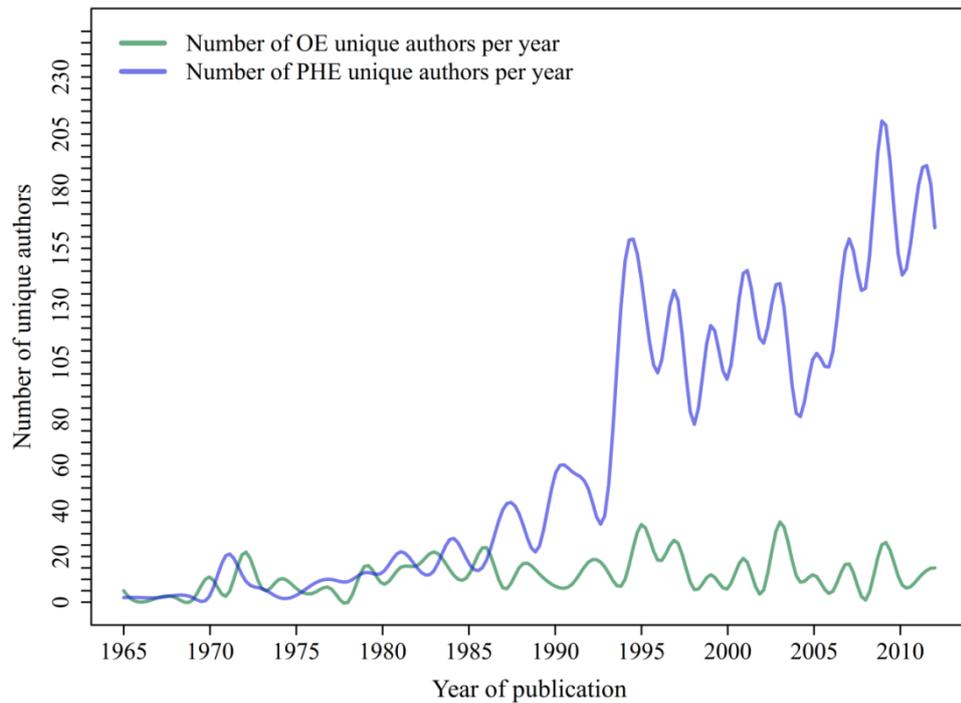


Figure 6-7: Temporal trend of new UK-based OE and PHE authors entering the field during the period 1965 –2012.

6.4.2.9 Collaboration

Two analyses are used as indicators of research collaboration in each field:

- Co-authorship analysis
- International collaboration- number of studies co-authored by international authors

Co-authorship analysis

Authors who published more than one article were counted for each published work. For example, T. Sorahan has published 35 articles during the study period, and thus his name is counted 35 times. Thus, the total number of authors, during 1965 - 2012, is 10942 in the field of PHE and 1236 in the field of OE. Table 6-4 shows the authorship pattern of PHE and OE fields. The number of co-authorship has increased in both fields over time but PHE shows higher rate of co-authorship contributions.

Table 6-4: Average number of authors per article over time

Year of Publication	PHE-average authors per article	OE-average authors per article
1965-1976	2.2	2.4
1977-1988	3.6	3.1
1989-2000	5.7	4.3
2001-2012	11.1	6.2
1965-2012	8.2	4.2

Articles that were published by 2 authors are the most frequent type in OE ($n = 67$, 22.8%), whilst, in PHE, the most frequently published articles are those that co-authored by 10 or more authors ($n = 237$, 17.8 %) (Table 6-5).

Table 6-5: Number and percentage of studies written by one to more than 10 authors

Number of authors/ paper	Number of OE studies	Number of PHE studies	OE studies percentage	PHE studies percentage
1	42	71	14.3	5.3
2	67	153	22.8	11.5
3	51	185	17.3	13.9
4	55	215	18.7	16.1
5	21	183	7.1	13.7
6	22	147	7.5	11.0
7	11	99	3.7	7.4
8	3	60	1.0	4.5
9	5	50	1.7	3.8
>10	20	237	6.8	17.8

Figure 6-8 shows that the percentage of studies co-authored by 5 or more authors is higher in PHE, whereas, the percentage of articles published by 4 or less authors is higher within OE.

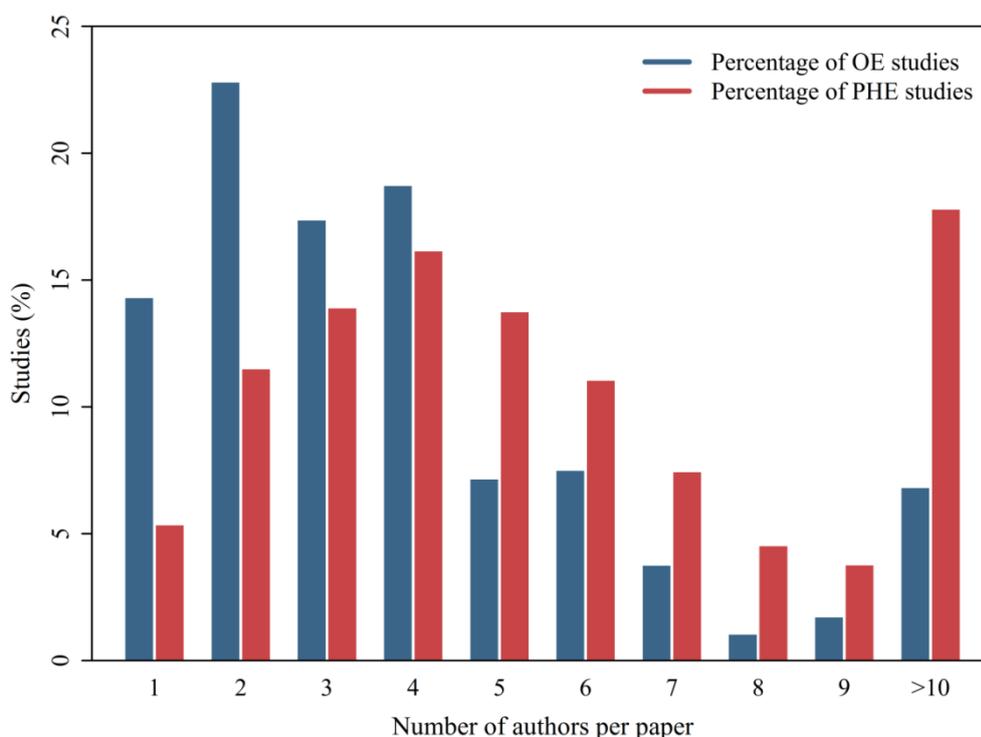


Figure 6-8: Percentage of OE and PHE studies authored by one to more than 10 authors

For the purpose of determination the co-authorship patterns, author field data was classified into three groups; one author, two authors, and three or more authors. The figures below show co-authorship patterns among OE (Table 6-9) and PHE (Table 6-10) researchers during 1965 - 2012. The results indicate that the level of productivity for single-author and two-authors have remained relatively low and stable over the years in both fields. The number of publications with three or more authors is increasing sharply within the PHE field, but not within the OE field. The data shows authorship by three or more is the dominant type of authorship in PHE (one article in 1965 increased to 68 articles in 2012, and peaked to 77 articles in 2009), and less so in OE. This could indicate that the level of collaboration (co-authorship) is higher among PHE researchers than OE researchers.

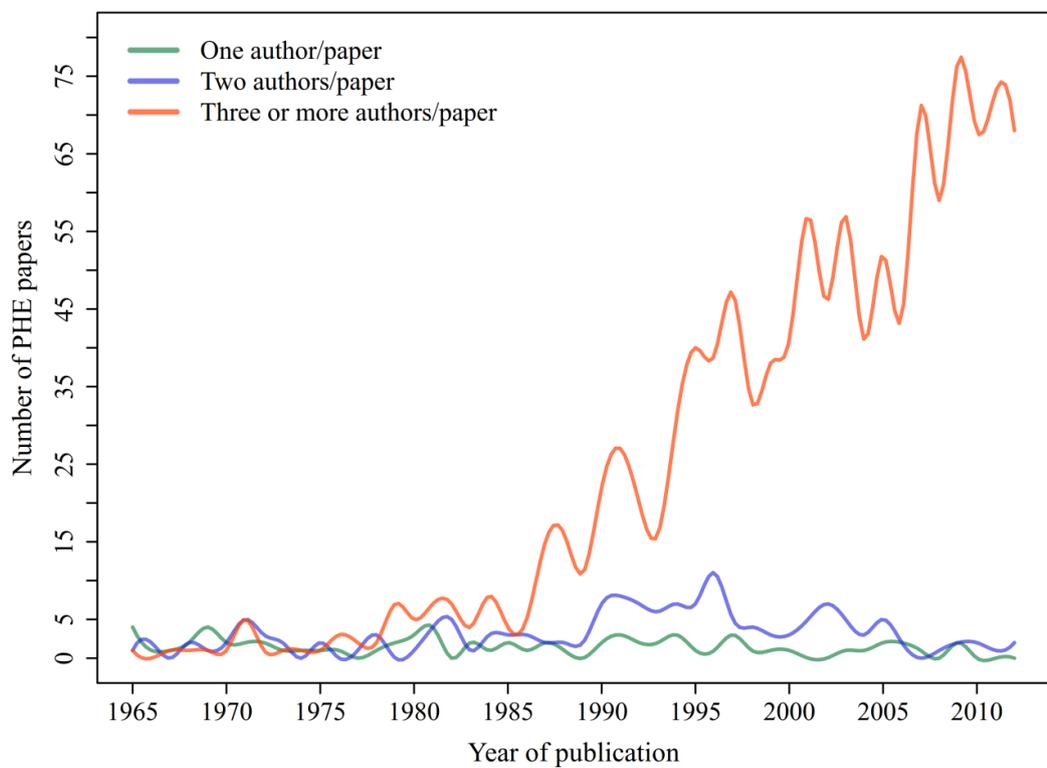


Figure 6-9: Trend of PHE co-authorship during the period 1965 - 2012

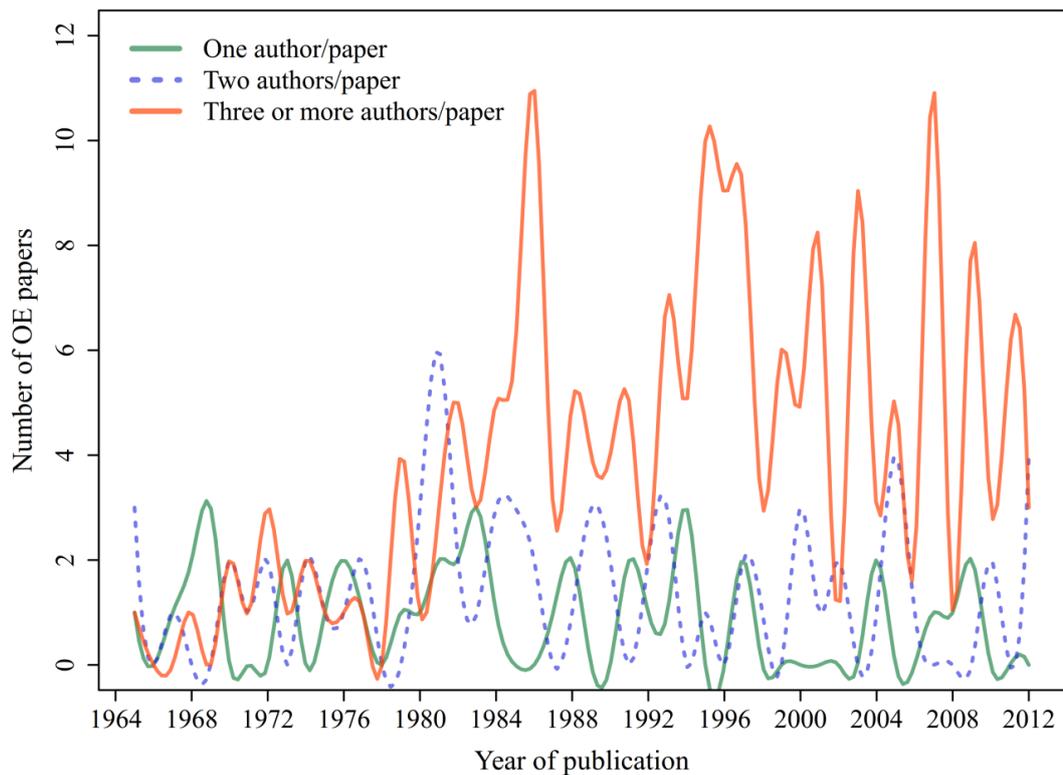


Figure 6-10: Trend of OE co-authorship during the period 1965 - 2012

International collaboration

In PHE, 1051 (78.8%) studies were conducted in the UK, and the remaining 282 (21.2%) were conducted in the UK in collaboration with researchers from 46 different countries. The level of collaboration was with the following decreasing order: USA (125 studies), Denmark (71 studies), Sweden (71 studies), Germany (69 studies) and France (68 studies).

In OE, 259 (88.0%) studies were conducted solely in the UK, and the remaining 35 (12.0%) were conducted in the UK in collaboration with researchers from 25 different countries. The main countries involved were France with 11 studies, USA and Australia with 7 studies each, besides Italy and Sweden with 6 studies each.

6.4.2.10 Top highly cited and productive authors

Authors were ranked according to their citation scores (PHE-Table 6-6, and OE- Table 6-8), which account for the total number of citations of their published articles identified in this study. However, when the lists are arranged based on the number of records they published in PHE (Table 6-7) and OE (Table 6-9), the lists of the author names has changed slightly; in particular for the last few names on the list.

The top 20 (0.5% of the total researchers and 0.7% of UK-based researchers) PHE authors published more than half of the articles in the field (58.7 %, n = 782) (Table 6-7). In OE, on the other hand, approximately similar percentage of the publications (57.5%, n = 169) was published by key 11 authors (1.8% of the total researchers and 2.0% of UK-based researchers) (Table 6-9). The top 20 OE researchers published 81.0% (n = 238) of the identified publications in the OE field (Table 6-9).

Table 6-6: Top 20 highly cited PHE authors and whether they are still active in the field

Author (PHE)	Active (Y/N)	No. of studies	% of studies	Citation score
Easton DF	Y	62	4.7	5924
Doll R	N	31	2.3	4776
Peto J	Y	28	2.1	3810
Ponder BAJ	N	33	2.5	3531
Bishop DT	Y	27	2.0	3324
Ford D	N	9	0.7	3275
Peto R	Y	7	0.5	2828
Beral V	Y	37	2.8	2750
Birch JM	Y	55	4.1	2622
Swerdlow AJ	Y	54	4.1	2233
Pike MC	Y	21	1.6	1936
McKinney PA	Y	59	4.4	1923
Alexander FE	N	36	2.7	1797
Cartwright RA	N	49	3.7	1727
Day NE	N	24	1.8	1709
Pharoah PDP	Y	31	2.3	1641
Key TJ	Y	34	2.6	1622
Goldgar DE	Y (not UK)	5	0.4	1566
McPherson K	Y	14	1.1	1547
Bulbrook RD	N	17	1.3	1479

Table 6-7: Top 20 productive PHE authors and whether they are still active in the field.

Author (PHE)	Active (Y/N)	No. of studies	% of studies	Citation score
Easton DF	Y	62	4.7	5924
McKinney PA	Y	59	4.4	1923
Birch JM	Y	55	4.1	2622
Swerdlow AJ	Y	54	4.1	2233
Cartwright RA	N	49	3.7	1727
Khaw KT	Y	47	3.5	863
Beral V	Y	37	2.8	2750
Alexander FE	N	36	2.7	1797
Riboli E	Y	35	2.6	1181
Key TJ	Y	34	2.6	1622
Roman E	Y	34	2.6	1305
Ponder BAJ	N	33	2.5	3531
Boeing H	Y (not UK)	31	2.3	1110
Overvad K	Y (not UK)	32	2.4	1112
Doll R	N	31	2.3	4776
Pharoah PDP	Y	31	2.3	1641
Trichopoulou A	Y (not UK)	31	2.3	1048
Tumino R	Y (not UK)	31	2.3	1085
Houlston RS- gen	Y	30	2.3	700
Smith GD	Y	30	2.3	1390

The above tables list the top 20 PHE authors with high citation scores (Table 6-7), and the top 20 PHE authors with the highest number of publications (Table 6-8). There are 11 author names appeared in both tables (names underlined) who share the highest citation scores (in the field of cancer epidemiology) and number of publications ($n = 481$, 36.0%). In Tables 6-7 and 6-8, there are 30 PH epidemiologists who published; articles with the highest citation scores, the highest number of articles, or a combination of both. From those 30 researchers, 17 (56.7%) are active UK-based researchers.

Table 6-8: Top 20 highly cited OE authors and whether they are still active in the field

Author (OE)	Active (Y/N)	Mainly OE researcher (Y/N)	No. of studies	% of studies	Citation score
<u>Peto J</u>	Y	N	8	2.7	1272
<u>Acheson ED</u>	N	N	17	5.8	1064
<u>Hodgson JT</u>	Y	Y	10	3.4	1037
<u>Doll R</u>	N	N	11	3.7	777
<u>Newhouse ML</u>	N	Y	8	2.7	775
<u>Sorahan T</u>	Y	Y	35	11.9	701
<u>Beral V</u>	Y	N	9	3.1	659
<u>Pannett B</u>	Y	Y	19	6.5	633
<u>Smith PG</u>	Y	N	6	2.0	619
<u>Coggon D</u>	Y	Y	20	6.8	557
<u>Carpenter L</u>	Y	N	5	1.7	513
<u>Berry G</u>	N	N	11	3.7	473
<u>Harrington JM</u>	Y	Y	13	4.4	422
<u>Winter PD</u>	N	N	12	4.1	415
<u>Cowdell RH</u>	N	N	3	1.0	411
<u>Gardner MJ</u>	N	N	10	3.4	378
<u>Jones JR</u>	N	Y	1	0.3	374
<u>Matthews FE</u>	Y	N	1	0.3	374
<u>Darnton A</u>	Y	Y	5	1.7	370
<u>Armstrong BK</u>	Y (not UK)	N	2	0.7	366

Table 6-9: Top 20 productive OE authors and whether they are still active in the field.

Author (OE)	Active (Y/N)	Mainly OE researcher (Y/N)	No. of studies	% of studies	Citation score
<u>Sorahan T</u>	Y	Y	35	11.9	701
<u>Coggon D</u>	Y	Y	20	6.8	557
<u>Pannett B</u>	Y	Y	19	6.5	633
<u>Acheson ED</u>	N	N	17	5.8	1064
<u>Harrington JM</u>	Y	Y	13	4.4	422
<u>Winter PD</u>	N	N	12	4.1	415
<u>Berry G</u>	N	N	11	3.7	473
<u>Boffetta P</u>	Y (not UK)	N	11	3.7	166
<u>Doll R</u>	N	N	11	3.7	777
<u>Gardner MJ</u>	N	N	10	3.4	378
<u>Hodgson JT</u>	Y	Y	10	3.4	1037
<u>Rushton L</u>	Y	Y	10	3.4	254
<u>Beral V</u>	Y	N	9	3.1	659
<u>Jones RD</u>	Y	N	8	2.7	243
<u>Newhouse ML</u>	N	Y	8	2.7	775
<u>Peto J</u>	Y	N	8	2.7	1272
<u>Fletcher T</u>	Y	N	7	2.4	95
<u>McDonald JC</u>	N	Y	7	2.4	142
<u>Osmond C</u>	Y	N	6	2.0	304
<u>Smith PG</u>	Y	N	6	2.0	619

The above tables list the top 20 OE authors with high citation scores (Table 6-8), and the top 20 OE authors with the highest number of publications (Table 6-9) (in the field of cancer epidemiology). There are 15 author names appeared in both tables (names

underlined), who share the highest citation scores and number of publications (n = 197, 67.0 %). From those only 8 researchers are occupational epidemiologist and the rest are primarily public health epidemiologists. There are unique 25 researchers in both tables with the highest citation scores, highest number of publications or both. From those, 15 researchers are active in the UK, however only 9 (45.0%) of them are primarily OE researchers.

6.4.2.11 Top Journals

The total number of journals in which OE studies are published is 56, and 250 for PHE studies. Approximately 50% (138 records) of the OE articles in the field of cancer are published in two (3.6%) Journals: Occupational & Environmental Medicine, and British Journal of Cancer (Table 6-10).

Table 6-10: Top 10 OE journals based on publication size and impact factor

Title of Journal	Number of papers	% of the papers	Mean IF‡ (1997-2013)
Occupational And Environmental Medicine (OEM)	114	38.8	2.480
British Journal of Cancer	24	8.2	4.126
Occupational Medicine	18	6.1	0.920
British Medical Journal (BMJ)	16	5.4	9.701
Scandinavian Journal of Work Environment & Health	15	5.1	2.178
American Journal of Industrial Medicine	10	3.4	1.514
Annals of Occupational Hygiene	8	2.7	1.552
Lancet	5	1.7	23.806
International Journal of Epidemiology	4	1.4	4.269
Archives of Environmental & Occupational Health	3	1.0	0.964
Total	217	73.8	51.51

‡ IF = impact factor

Approximately 50% (687 records) of PHE records are published in 10 (4.0%) journals listed in the Table 6-11.

PHE studies tend to be published in a higher impact factors journals (total top 10 journals mean IFs = 64.8) than OE (total top 10 journals mean IFs = 51.5). Furthermore, it is worth noting that almost half of OE studies were published in two journals with an average IF of 3.3; however, half of PHE studies were published in 10 journals with an average IF of 5.2. Interestingly, slightly higher percentages of PHE studies were published in two highly ranked and prestigious journals than OE studies. In this regard, 8.1% of PHE studies were

published in BMJ and the LANCET (5.1% and 3.0% respectively), compared to 7.1% (5.4% and 1.7% respectively) of OE studies. Additionally, 17 (6.6%) of the OE studies published in these two journals between 1970 to 1995, and only 3 (1.2%) studies published in BMJ; one in 2003 and two in 2009. In PHE 47 studies (3.5%) were published between 1970 and 1991, and 58 studies (4.6%) were published between 1992 and 2012.

Table 6-11: Top 10 PHE journals based on publication size and impact factor

Title of Journal	Number of papers	% of the papers	Mean IF (1997-2013)
British Journal of Cancer	280	21.0	4.126
International Journal of Cancer	68	5.1	4.480
British Medical Journal (BMJ)	68	5.1	9.701
Journal of Epidemiology & Community Health	54	4.1	2.569
European Journal of Cancer	49	3.7	3.867
Cancer Epidemiology Biomarkers & Prevention	50	3.8	4.229
Lancet	40	3.0	23.806
Cancer Causes & Control	34	2.6	3.037
American Journal of Epidemiology	23	1.7	4.719
International Journal of Epidemiology	21	1.6	4.269
Total	687	51.5	64.803

6.4.2.12 Top productive institutions

There were 32 articles of unknown institutions in OE and 56 in PHE. These articles were screened manually and authors' and co-authors' institutions in all articles were extracted and sorted manually for further analysis.

There were 253 institutions from which OE studies were produced, and 1340 institutions from which PHE studies were produced. This included national and international institutions. The top 10 productive institutions are listed in Table 6-12 for OE and Table 6-13 for PHE. Five of the top institutions (indicated with an asterisk next to institution name) are common in both fields, whilst the other half is unique to each field reflecting the institutions that are mainly conduct this type of research (e.g., Health & Safety Executive for OE studies). It was also noted that two international institutions (in collaboration with other UK institutions); International Agency for Research on Cancer (IARC) and Danish Cancer Society, produced 3.7% of the OE studies and 3.8% of the PHE publications respectively.

Table 6-12: Top 10 institutions that have published leading OE papers

Institution	No of publication	% of publication	Total citation count
University of London*	46	15.6	1727
University of Birmingham*	36	12.2	813
University of Southampton	33	11.2	1219
University of Oxford*	28	9.5	1207
Health & Safety Executive	27	9.2	962
University of Manchester*	13	4.4	295
Institute of Cancer Research*	12	4.1	366
International Agency for Research on Cancer	11	3.7	182
Institute of Occupational Medicine	10	3.4	149
MRC	8	2.7	341

Table 6-13: Top 10 institutions that have published leading PHE papers

Institution	No of publication	% of publication	Total Citation count
University of London*	265	19.9	9845
University of Oxford*	193	14.5	10636
University of Leeds	136	10.2	3981
Institute of Cancer Research*	127	9.5	8173
University of Cambridge	118	8.9	4649
University of Manchester*	81	6.1	2773
University of Edinburgh	57	4.3	2803
University of Birmingham*	56	4.2	3077
University of Bristol	52	3.9	3027
Danish Cancer Society	51	3.8	2515

6.5 Discussion

The purposes of this phase of the study were; to analyse the characteristics of OE literature over a defined period of time and compare it with PHE literature, in the field of cancer, and to identify any emerging patterns and trends in both fields and explore the likely reasons for differences that can be identified. The study results show that the number of publications in OE remained relatively constant over the study period; whereas; in PHE, the number of publications increased substantially, particularly since 1985. Over the study period, similar trends have been observed for the publication citation scores and the number of new researchers in each field (an average of 63 PHE new authors compared to 11.7 OE new authors per year).

The key differences between OE and PHE literature is that PHE; is slightly more cited (41.6 citations per PHE paper versus 37.5 per OE paper), is published in slightly higher impact factor journals, employs new methods and techniques in higher proportion of its studies (25.4% of PHE studies versus 2.7% of OE studies), and its publications has noticeably higher level of national and international (21.2% of PHE, and 12.0 of OE studies) collaboration (i.e., more authors [8.2 authors per PHE paper versus 4.2 OE authors per paper] and institutions per paper).

The characteristics of literature in each field are discussed along with any existing similarities and differences. This includes discussing key results in relation to relevant literature.

The discussion is presented under the following key issues:

- 1- Citation trends and characteristics
- 2- Collaboration
- 3- The impact of use of new methods and techniques
- 4- The impact of scientific and technological development
- 5- Key researchers' characteristics and influence
- 6- The impact of funding

After discussing the above issues, the study strength and limitations are presented, followed by conclusions and recommendation for future research.

6.5.1 Citation trends and characteristics

6.5.1.1 Citation trends

Citation might give an indication of the usage of the articles in each field and thus the more the article is cited the more it contributes to the field (Glanzel, 2003). The number of

citations may not necessarily relate to the originality, importance or even the quality of that work, but is a measure of its impact and/or visibility in the field (MacRoberts & MacRoberts, 1989). Also, it may be utilised in different fields which may indicate its multidisciplinary importance and contributions. Authors nonetheless use citations for various intentions and meanings (Garfield, 1998). Leading researchers often supervise a large number of students, and their articles are more likely to be cited than are those of their less influential counterparts. Authors may perhaps refer to eminent experts/leading authors as a tribute rather than in acknowledgement of a piece of work they favour (Bornmann & Daniel, 2008). References could also be negative, for example, an author may possibly be cited for research of a debatable nature or for inaccuracy in methodology (Aström & Sándor, 2009). Self-citation, where researchers reference to their own past work, should also be considered. In this study too, citation does not always measure the quality of research but rather the impact of a particular field, study or of an individual researcher.

On the other hand, assessing the impact of a particular research field cannot be sufficiently addressed by citation analysis alone. For example citation analysis alone cannot demonstrate if the research resulted in policy change, improvement or changes in health and health care systems (Sarli, Dubinsky, & Holmes, 2010). Some researchers suggested utilizing other methods in addition to citation analysis (i.e., using mixed-methods including consultation with subject experts, documents review, and key informants' interviews) (Brueton, Vale, Choodari-Oskooei, Jinks, & Tierney, 2014; Sarli et al., 2010). They also provided frameworks for assessing the impact of clinical (Sarli et al., 2010) and methodological (Brueton et al., 2014) research. The frameworks provided key themes under which the impact of research can be quantified including; research outputs, advancement of knowledge, implementation of findings, community benefit, legislation and policy, and economic benefit. However, the above-mentioned frameworks were designed for clinical and methodological research rather than epidemiological studies. Some of the themes might be applicable to epidemiological studies (e.g., community benefit, and legislation and policy); however, there might be other issues that are either difficult to measure, such as economic benefits (e.g., economic gain from linking smoking to lung cancer), or not addressed in these frameworks. Furthermore, these frameworks are designed for a small number of and recently published studies, and yet were laborious in nature as described by the authors. Therefore, it was not possible, considering the aim of the study and the time scale, to use other indicators to assess the impact of OE and PHE studies.

A noticeable finding is that PHE articles published between 1995 and 2005 are cited more than articles published before 1995 or after 2005. The decrease in the number of citations after 2005 can be explained by the length of time that is required for an article to be cited. Citations are given after publications and recently published articles generally require more time to be cited; hence, citations of articles published after 2005 is lower than preceding articles. For example, an article published in the year 2000 is likely to be cited more than an article published in 2005, and so on. Van Raan (2003) called this period “citation window” which, according to him, should be five to six years in the social sciences, and two to three years in natural sciences.

This citation trend may possibly mean that PHE authors tend to cite recently published articles more than those published earlier. Hargens (2000) identified two major scholarly structures, one in which scholars focus on recently published research while tending to ignore foundational work, the other in which scholars focus on early work while tending to ignore recent publications. According to Hargens, the natural sciences tend to fall into the earlier category, while the humanities and social sciences fall into the second. The study findings support Hargens’ assertion; in that, epidemiology is a branch of natural sciences, in which current research so thoroughly incorporates the past scholarly achievements that it is not essential to acknowledge original sources (Hargens, 2000). In fields with this structure, scholars build on recently published findings, and the time between the publication of a new finding and its incorporation in subsequent work is short (Price, 1986).

In contrast, citation scores of OE studies remain relatively constant over the years. In part, this could be the result of publishing patterns in different subfields; nonetheless it could also be a reflection of the communication networks and social norms in which subfields operate. This may also be explained by the small number of researchers and thus the number of articles published each year in OE, compared to PHE, rather than because OE researchers utilise literature differently or OE studies have a different pattern of citation structure. Interestingly, this could mean that the usability and hence citations of this type of study is mostly by authors within each field; however, this was not reflected in the data as the local citation scores (the citation scores of the retrieved articles from the same sample) in both fields is considerably smaller than the global citation score (not shown).

6.5.1.2 Top cited articles

The results indicate that OE researchers during 1970s and 1980s published more influential studies than current researchers. Albeit, some of the researchers listed above may also be still active, they have not produced studies of the same influence of their previous studies.

The opposite phenomenon is observed within PHE; where the main key studies were published more recently compared to OE studies. These results show that, although both fields published relatively similar percentages of studies in high impact factor journals, yet the quality of OE studies might have decreased over time, whereas the opposite trend is observed in PHE studies (i.e., PHE studies quality improve over time). This could indicate that highly influential researchers entering PHE and leaving OE field (e.g., through retirement, death or moving to other areas) over time. Furthermore, the fewer researchers joining OE field might have an influence on this trend.

However, there might be other factors that could explain this shift, which require further examination. For example, has there been a shift in OE researchers' interests towards diseases other than cancer? Has funding shifted towards studies involving more new methods and technologies?

6.5.1.3 Top journals

Both fields publish half of their papers in 4% of the total journals. A total of 122 of the identified journals published one PHE study each (50% of the total journals). This pattern is also observed in OE publications; a single article is published in each of the 26 identified journals (54% of the total journals identified). Both fields followed the same phenomenon and same publication behaviour pathway.

Bradford S. confirmed that a relatively small number of journals publish the bulk of significant scientific results (Garfield, 1998). This principle is often referred to as Bradford's Law (Garfield, 1998). This result supports Bradford's argument as half of each field's studies are published in only 4% of the total journals. It has also been reported by Gehanno & Thirion (2000) that 1.4% of journals in the field of Occupational Health ($n = 8$) account for 27% of published articles in the field.

It can be argued, however, that the growth in PHE publication activity could be a reflection of the growth in MEDLINE database coverage as more new journals could have been added over time (Bellis, 2009). Nonetheless, it is reasonable to assume that the growth in database coverage will affect both OE and PHE in the same way. Additionally, as shown above, the majority of the articles in both fields are published in few journals, which are covered by the database throughout the period of this study.

6.5.2 Research collaboration

The study has shown that national and international collaboration may further have contributed to the growth of PHE, which was less evident in OE. Moed (1989) suggested that groups that share their intellectual focus with other researchers tend to achieve higher citation scores than groups working more on their own. The study findings support Moed's theory; that is, collaboration level (co-authorship), as an indicator for sharing ideas amongst PHE researchers is much higher than that among OE researchers.

Issues such as specialisation and the growth of multidisciplinary research have encouraged researchers to cooperate with each other. Because of the nature of fields and the differences among them, scientific collaboration in various scientific fields is different. In some fields, access to laboratory facilities and manpower in a research project is greater than others, which involves more collaboration and cooperation with other fields to achieve the project aims. Probably because current OE studies tend to be classical (for instance it continues to rely primarily on questionnaire assessment of exposure instead of using biological markers of exposures (e.g., DNA)) and do not considerably involve the use of the new technologies; its members might be less prompted to seek collaborations with other disciplines.

Whereas PHE employed more frequently cutting edge techniques that require more financial, expert and technical support in order to incorporate these in research studies. It is noticeable that more studies utilised data from international large cohort studies/databases (e.g., EPIC, Genome-wide association study, Members of the European Network of Cancer Registries (ENCR)) in PHE than in OE, in which UK has contributed to the collection of such data. However, the reason for the lack of OE involvement in these studies merit further investigation.

6.5.3 The impacts of the use of new methodologies and techniques

The recent advances in molecular biology and genetics have made it possible for researchers to examine how genetic characteristics affect responses to occupational and environmental exposures (Schulte, Whittaker, & Curran, 2015). These methods and techniques have been used in epidemiology for better understanding of the underlying mechanisms of disease and therefore ultimately contribute to Public Health (Schulte et al., 2015; Teare, 2011b).

There has been an increasing interest in applying molecular and genetic techniques in epidemiology worldwide (Donatella Ugolini, 2007; Takahashi et al., 1996). Ugolini (2007)

showed an increase of 148% in the world publication of cancer molecular (including genetic) epidemiology between the first biennium (1995-1996) and the last biennium (2003-2004) of their study. They also found that Europe and the USA have produced the highest number of studies ($n = 1421$, and $n = 1216$ respectively). Amongst European countries, the UK produced both the highest quality and quantity of studies by generating 20.8% ($n = 295$) of total European papers (Ugolini, 2007).

The UK is one of the most productive countries in producing molecular and genetic epidemiology studies in general (Ugolini, 2007), this productivity was not manifested in the field of OE as shown in this study. This study shows that, in the UK, these recent advances in molecular biology and genetics have been employed more frequently in PHE (339 studies) compared to OE (8 studies). Investigations in molecular and genetic epidemiology tend to be very costly (Axelson, 1994), which suggests that PHE may have received relatively more funding than OE. However, this also suggests that these techniques could be attractive to funding bodies as revealed in the previous phases of the study (see Chapter Five). OE researchers underlined that other health studies involving molecular and genetic techniques, which are rarely used in OE, tend to attract more funding.

On the other hand, despite the potential benefits of genetic information, its collection in occupational settings presents ethical, legal and social challenges (Merletti, Mirabelli, & Richiardi, 2007). For instance, genetic information could be used to discriminate against workers (Axelson, 1994). Employing these techniques in OE studies is thus potentially more challenging in terms of gaining study ethical, management and workers approvals. This may well be one of the reasons for this lack of these methods and techniques within OE.

It is worth mentioning though that molecular and genetic epidemiology is possibly underrepresented compared to other classical epidemiology in this study. This is because, in this study, articles retrieval was primarily based on MeSH term search and did not include keyword search in relation to epidemiological studies. Nonetheless, there is a lack of MeSH terms referring to molecular genetic studies in general (Ugolini, Neri, Casilli, & Bonassi, 2010). There is also difficulty in indexing molecular and genetic studies because of the lack of appropriate MeSH terms in the title and/or abstract related to the typical type of epidemiological study (e.g., a case-control study or cohort study) (Ugolini et al., 2010).

6.5.4 The impact of scientific and technological developments

The growth of OE has most likely been affected by the significant scientific and technological advancement during the last few decades. Such advancements have implications on the workforce and workplace environment, as well as on the types of work. Consequently, the focus of OE studies has frequently changed. For instance, occupational diseases during 1960s-70s were linked with industrial poisoning (e.g., cancers, skin diseases). However, due to scientific advancements in diagnostic techniques and biomedical sciences several other diseases and work related medical conditions have been identified thereafter such as; noise-induced hearing loss, musculoskeletal, several bronchopulmonary diseases and mental health disorders.

This frequent change of focus is evident in the list of occupational diseases documented by the International Labour organization (ILO). The ILO list, which is a collection of diseases caused by exposure during work, was initially established in Germany for the purpose of identifying compensable workers' diseases (Kim & Kang, 2013). The list subsequently has become officially recognised by international and national legal systems in many countries for both compensable occupational diseases and the prevention of these (Walters, 2007). In 1964, the list included 10 occupational diseases (9 types of industrial poisoning and 1 infection). In 1980, an addition of 7 more types of chemical poisoning, respiratory disease, disorders caused by physical agents, skin disease and infectious disease have been incorporated into the ILO List (Kim & Kang, 2013). This change reflected the era of extending the focus on occupational disease beyond occupational poisoning. Since then, the structure of industry has changed and moved from heavy industries toward service fields, new potential workplace risks have emerged (e.g., new industrial chemicals, nanotechnology), and the workers' compensation policy has been developed (Walters, 2007).

In the latest update of the list, in 2010, it encompassed 41 chemicals, 7 physical agents, 9 biological agents, 12 respiratory diseases, 4 skin diseases, 8 musculoskeletal diseases, and 2 mental and behavioural disorders (Walters, 2007). In the UK, prescribed diseases (i.e., compensable workers' diseases) increased from 3 new prescribed diseases (3 respiratory conditions) identified in the decade of 1950s to 12 new prescribed disease (6 musculoskeletal conditions, 3 cancers, 2 respiratory conditions, and 1 neurological disease) in the decade of 2000s ('UK Government Web Archive – The National Archives', n.d.). Similarly, this expansion reflects the further development in technological and biomedical sciences as well as shift in work and workplace exposures. For example, the traditional

stresses, which were largely biochemical or physical in nature, have now been largely replaced, in certain types of occupation, by psychological ones.

The evidences exploited to decide on the prescribed diseases in the UK were based on national as well as international studies. It took long time to prescribe some old occupational diseases of long latency because of lack of evidence. For example, lung cancer in oven coke workers was reviewed in 1986; however due to limited evidence base at that time the disease was not recommended for prescription (Industrial Injuries Advisory Council, 2011). The evidence was reviewed in relation to this disease 25 years later (in 2011) and prescription was recommended based on national and international studies. The reviewing committee thought that the exposure levels to carcinogenic agents are likely to have reduced significantly since the 1970s, due to improvements in engineering and personal safety controls in the industry. The committee however, could not define a cut-off date where prescription would no longer be granted. This was again because of insufficient evidence.

Therefore, OE has perhaps not adequately maintained its efforts with the rapid changes in occupational exposures and workplace environment, hence the slow growth compared to other epidemiological disciplines. Lack of expertise was one of the issues OE researchers highlighted in the previous phases of the study, where some specialities; such as occupational hygiene training has not been adequately available in the UK (Coggon, 2010). This is besides the fact that methodological advances (e.g., toxicology and risk assessment, molecular and genetic methods and meta-analysis) (Checkoway et al., 2004) require an adequate level of multi-disciplinarity to be able to tackle the current health issues, which seems to be lacking in OE as opposed to PHE. For instance, 68% of the questionnaire respondents, in the previous phase, are epidemiologists, statisticians and physicians.

Furthermore, occupational physicians play a major role in identifying work related disease clusters; however, the number of occupational physicians and the academic base for occupational health in the UK has declined over the years (Black, 2008a; Coggon, 2010). McDonald (2002) found that only 12% of the overall working population in the UK have access to occupational physicians' services. As discussed above, the motive for this decline has been the decline of heavy industry (e.g., coal mining, metal manufacture industry), the growth of employment in service sector, which primarily less hazardous, and the success of measures to control hazardous exposures and activities (Coggon, 2010).

In addition to challenges posed by the science and technological advancement, many occupational diseases can take long time to be attributed to work due to legal and compensation reasons. An example of such difficulties is hearing loss due to workplace noise, which took 40 years to be acknowledged due to legal and compensation reasons (Kim & Kang, 2013). Some OE researchers reported pressure and resistance from industry corporates to accept the findings from OE studies, as well as blocking publications especially if the source of funding was the industry itself (Pearce, Checkoway, & Kriebel, 2007). Some of the interview phase participants also drew attention to the difficulties they experienced with industry. One particular researcher, for instance, reported concerns about a particular hazard in certain industry, but the industry did not allow access to workforce for legal reasons and fear of litigation. Therefore, the work of OE is typically more challenging (e.g., by insurance and workplace legal and managerial regulations) than that of PHE, which generally is better supported by the public and government bodies.

6.5.5 Key researchers' characteristics and influence

Interestingly, a small percentage ($n = 20$, 0.7 % of the total PHE authors) of UK-based PHE authors published more than half (58.7%, $n = 782$) of PHE studies. Of those, 12 (60%) PHE are still active in the field. Whilst slightly higher percentage of OE authors (2%, $n = 11$) published approximately similar percentage (57.5%, $n = 169$) of OE studies, only 5 (45.5%) of them are still active in the field.

These results provide two interesting findings. Firstly, the number of key researchers in OE field is getting smaller as only 7 (i.e., top cited and/or productive; 1.1% of the total UK-based authors) of them are currently active and the majority are approaching retirement. This finding confirms the key findings of the previous phases of the study and shows that the perceptions of OE researchers, regarding the aging of key researchers and the difficulty recruiting new researchers to the field, are a true reflection of the current situation. Particularly that an average of 12 new researchers enter OE field each year, which reflects the small number of research projects that get funded each year. The majority of these projects may well be granted to leading research teams in the field.

The second issue concerns the key UK-based PHE researchers. They are relatively younger than OE researchers (based on personal knowledge of the key OE researchers identified in the list), and more specialised and focused on certain areas of epidemiology. For example, the PHE most cited and productive author Easton, DF is a leading researcher in cancer genetic epidemiologist, whilst the second most productive OE author Coggon, D is a

leading researcher in several OE areas such as musculoskeletal, cancer, infectious, and dermatological diseases. This focus and specialisation of PHE researchers might have contributed to their fast progression and success in gaining funds for their projects in the field. This also might partially explain despite the significantly higher number of publications in this field compared to OE, 0.4% ($n = 17$ currently active UK-based researchers) of them dominate the field (publishing 45.4% of total publications, $n = 605$).

In the early years, epidemiologists carried out cancer epidemiological studies in all fields, whereas nowadays several subfields diverged from PHE, such as nutritional, molecular and genetic epidemiology (Ahrens & Pigeot, 2007; Bonita et al., 2006), hence researchers might have become more specialised and focused in one area. The interview phase participants highlighted that the few leading institutions that conduct OE research do not have an independent OE department and it is typically part of or under an overarching department such as environmental epidemiology or public health. This may be an indicative of the lack of speciality and focus, as well as, the small size of its community.

However, there are issues that cannot be explained fully here and certainly deserve further examination. For example, why do the leading researchers continue to get funding for their projects? Do funding bodies grant them regular funding on the basis of their reputation, employing organisation (e.g., whether it is part of a funding body), or personal knowledge of them or there are other biases?

6.5.6 The impact of funding

Publications are the primary scientific research output where new scientific discoveries are conveyed to the world (Nelkin, 1998; Rennie D, Yank V, & Emanuel L, 1997). For researchers, publications also play a major role in achieving academic recognition and promotion (Horton, 1998). On the other hand, health and biomedical research are often expensive, requiring extensive human and financial resources. Without a sufficient and stable sources of funding, outstanding research is very difficult, if not impossible, to achieve (Teare, 2011a). National funding capacity for research is thus, likely to be an important factor impact on publication output. Therefore, the difference in publication rate between OE and PHE potentially might be due to external factors such as funding and funding policies.

Tompkins and colleagues (2001) supported this notion by showing a temporal linkage between decreases in research funding and a drop in the number of publications in the US.

Similarly, another study indicated that developed countries, which invested large amount of funds in research, were generally the ones that had the highest publication output (Man, Weinkauff, Tsang, & Sin, 2004). One can therefore speculate that OE research has maintained relatively the same level of funding over the years, whilst PHE research funding has exponentially increased particularly since mid-1980s.

The decision to fund OE studies could be influenced by the ongoing improvement of occupational exposure control and preventative measures in workplace environment. Once occupational hazards are recognised to causes diseases they become subject to regulatory control, and hence particularly suitable for prevention. This is contrary to many aspects in PHE such as lifestyle risks (e.g., smoking and dietary habits), for which less imminent and more difficult to achieve controls are involved; such as modification of cultural and personal behaviour patterns. The UK was the first to prohibit manufacturing of certain substances because of their carcinogenicity (e.g., beta-naphthylamine, benzidine, 4-aminobiphenyl and 4-nitrobiphenyl) through the Carcinogenic Substances Regulations in 1967 (Gadian, 1972; Merletti et al., 2007). The HSE additionally plays a key role in implementing preventative measures and controls in workplace environment through regulations, law enforcement and inspection of workplace. Therefore, occupational hazards could be perceived less of a problem, particularly due to the long latency of some of the occupational diseases (e.g., lung cancer) (Rogers et al., 2009); funding OE research hence might have been of a lower priority throughout the years of ongoing workplace environment improvements. Furthermore, funding bodies may not be interested in funding areas where health and safety legislations are in place.

6.6 Conclusions

This study provided evidences about the size and growth of OE, in the field of cancer, in comparison with PHE. PHE has developed and its popularity has increased over the years; while OE has maintained its size, and continued to produce approximately the same number of studies over the years. OE studies are not necessarily of a lower quality than PHE studies. However, the field has not developed over the years compared to other epidemiological fields, and fewer branches have evolved from it.

Several factors may account for this difference in trends and developments; collaboration, adapting 'New' methods and techniques (e.g., molecular and genetic techniques), scientific and technological advancement during recent decades and their implications for the

workforce and workplace environment, the influence of leading researchers, and more importantly funding availability.

There is no doubt that policies and political power drives research as well as influencing its sustainability by influencing and controlling funding (Teare, 2011a). It is possible then to argue that more funding had been available to PHE, which might influenced its key researchers to focus their efforts on one area and produce more studies. However, in OE the likelihood it lacked funds, might have obligated researchers to work on several OE areas, or switch their efforts to other epidemiological fields, where funding is available. Therefore, research groups might have integrated or moved partially or completely to other epidemiological areas with occasional and opportunistic OE work; hence such groups' efforts might have been diluted into several fields.

6.7 Future research

There are many factors that have influenced OE development; however, the availability of funding to carry out OE studies potentially could have the greatest impact. As the study shows, funding can be potentially interwoven with most of the issues discussed above; such as employing cutting edge techniques, perceptions of funding bodies and views of policymakers of whether OE studies are required, the level of collaboration and the role of the key researchers. Nonetheless, the study does not explain what influence the decisions of allocation and distribution of research funding. On what basis funding is allocated? Who are the decision makers and what influences their decision to fund certain types of studies or fields and not others? Are their decisions are based on scientific evidence, a public need for a study to be conducted, particular policies, or other social, economic issues? To improve understanding, these issues were explored in relation to the trends identified in this phase of this study, and in reference to policies of funding bodies and allocation of funds in the final phase of the study. This was done by conducting a documentary review of key funding bodies' annual review reports.

7 THE IMPACT OF FUNDING POLICIES AND ALLOCATIONS ON THE RISE AND FALL OF HEALTH RESEARCH DISCIPLINES

7.1 Introduction

This chapter presents the documentary review phase of this study, which comprises an analysis of formal documents created by funding bodies operating in this area. It is divided into three sections. The first section describes the background, aims and objectives and the research method utilised (including the rationale for its use, and strengths and weaknesses of this approach. In the second section, the findings are presented. Finally, the findings are discussed in relation to the objectives of the study and relevant literature.

7.2 Background

The interview and survey phases of this study indicated that the greatest challenge facing the OE researchers, in the UK, is the lack of resources available to support OE studies. Participants in these phases also emphasised that the field has become less attractive to investment by major funding bodies. As a result, conducting OE studies has become more challenging over the years, particularly since mid-1980s as shown in the bibliometric study. The bibliometric study also indicated that, in the field of cancer, the numbers of PHE publications and researchers has increased significantly since 1980s, whilst in the OE the numbers remained fairly constant.

There were many possible interwoven issues that might have contributed to these results and the differences in trends between PHE and OE as shown in the bibliometric study. These include the differences in the degree to which cross-disciplinary collaboration takes place, the use of newer methods and techniques in PHE, and the impact of deindustrialisation on the recognition of the importance of OE by funding bodies. These

issues; however, do not adequately explain why resources are available to certain studies or fields and the motivations and implications of these decisions. A more in-depth investigation and understanding of these issues may provide a more comprehensive overview of OE challenges and facilitators and how they have evolved.

Furthermore, the indicators discussed above could also be interlinked with the politics of funding bodies, their policies and allocation of funds. For example, collaboration has been encouraged by funding bodies (Banal-estanol, Jofre-Bonet, & Meissner, 2009; Defazio, Lockett, & Wright, 2009; Furman & Gaule, 2013), and one would expect studies with a higher level of collaboration could be more successful in securing funding.

Additionally, funding problems could potentially cause the greatest effects. This is because, as stressed by the key researchers in the interview phase (section 4.4.5), studies could not have been carried out if funds were not available, and most of the anticipated practical difficulties could be resolved if enough resources are available (e.g., training new researchers, recruiting participants, developing techniques or buying necessary equipment). Thus, exploring policies of funding bodies and funding decisions may further illuminate the data emerging from the earlier phases of the study.

7.3 Aims and objectives of the documentary analysis phase

The documentary analysis phase aimed to: (i) explore health research funding mechanisms and policies of key UK biomedical and health research funding bodies including their role in the allocation of research funds and their relation to the development (or lack of it) of certain health research fields; (ii) identify any external social, economic and political issues that might have influenced the decisions and policies of these funding bodies; and (iii) to examine how these issues could explain further how relevant challenges and facilitators in the OE field have evolved compared to other health research fields.

The specific objectives of the documentary analysis are:

- to elucidate the process or procedures employed by funding bodies in research funding allocation and justification of the allocation of funds;
- to understand why funding schemes of particular programmes are initiated and ended;
- to examine the role of certain policies, leadership issues; including those of the funding bodies and the recipients of the funds (i.e., researchers);

- to identify any external issues, such as social, economic and political factors, and discuss the potential influence of these on funding decisions and policies of these bodies;
- to explore the relationship between funding and research collaboration, as well as, the use of new methods and techniques;
- to discuss the implications of the findings in relation to further understanding of the challenges and facilitators of the OE field as well as other health research disciplines.

7.4 Method selection

A qualitative approach using interviews could have been utilised to achieve the aims and objectives of this phase of study. Participants could have been chosen purposefully from certain funding bodies and research disciplines. However, the difficulty was deciding on which participants and disciplines should be included. Choosing a certain research groups, researchers and funders might not shed light on understanding the general issues of funding decisions. Additionally, bias of the participants towards certain paradigm or school of thoughts, particularly when discussing historical events, might be unavoidable. Furthermore, finding appropriate participants for this study would have been most likely problematic. This is because such participants might have retired, deceased or very difficult to recruit; for example, considering their responsibilities, they could be busy to be interviewed.

Quantitative approach by means of a survey method is also difficult because of similar type of challenges as those discussed in the interview method (section 4.4.2). Therefore, in order to achieve the study aims and objectives, a documentary analysis was deemed the most appropriate and chosen for this phase of the study. This method and its strength and limitations are discussed next. Documentary research in health and social sciences, although underutilised, is a rigorous scientific method, which has been utilised successfully by other researchers (May, 2001; McCulloch, 2004; Mogalakwe, 2009; Scott, 1990). In the following sections, the documentary review method is discussed including its advantages and limitations and how it was applied in this study.

7.4.1 Advantages of the documentary analysis

Documents have generally been used for research purposes, especially in historical research (May, 2001; Scott, 1990). Documents can be more objective than relying on participants' recall, also they are a valuable source of data when no other data source is available (e.g.,

participants or statistical data), which was the case for this study (May, 2001; Scott, 1990). Documents are powerful; they can make things visible and traceable as well as be the mediators in and give structure to social interaction (Prior, 2003).

Documentary research can be conducted along with other methods, such as surveys and observational data, to enhance understanding by providing historic context to contemporary events (May, 2001; Scott, 1990). It can also allow comparison between the observers (for example; researcher or research participants) interpretations of the events and what is actually documented about these events (May, 2001). Documentary research can also be conducted in its own right. It can provide information about how events were constructed, the reason behind this construction, and it can also provide data upon which further research can be conducted (May, 2001).

For the above reasons, documents are studied to bring understanding to culture and to study the process and meaning of social activities (Altheide, 1996). In this study, documents were studied to understand the funding mechanisms in scientific and academic culture, and to understand how scientific research funds were allocated and which individuals and organisations were involved in this social process.

Using historical records, the researcher is rarely in a position to influence those who originally produced those records. Moreover, those producing the documents are unlikely to assume the material would be subject to research in the future. Related to this issue, Murphy & Dingwall (2003, p. 66) stated that organisational documentation is subject to possible social desirability bias, but they argue it is valuable for that same reason, as records of *'what people and organisations would like to be thought to be doing'*. This is particularly useful in this study through exploring funding bodies' policies and leaders' motivations at that time, in relation to supporting (or lack of support) specific areas of scientific research. Relevant questions included an analysis of what they thought was important to merit support or not worthy of further funds and why; and whether there was evidence of any internal and external factors that influenced their decisions, such as social, economic and political issues.

Documents in research are used as resources, where the document is a source for studying a specific subject, and topics where the focus is the nature of the documents (Scott, 1990). Accepting the content of a document, without examining how and why it was produced, can be misleading. Therefore, when using data from documents sources, *'the researcher's*

main concern is to explain the nature of the documents themselves; they are regarded as social products and are treated as the objects of sociological analysis. The aim is to elucidate the social processes through which they were produced in order to explain their form and content and perhaps something about their authors and the circumstances in which they were living.' (Scott, 1990, p. 36). An example of using a document as a topic is through looking at the background of the authors, the motive and the political circumstances surrounding the document's construction. However, this is not always obvious, particularly when assessing organisational or policy documents, when authors are not always known for part or for the whole document.

Documents are seen to have an impact on the characteristics of organisational communication through their form and material qualities (Riles, 2006). In the light of this, documents, such as annual reports published by funding bodies, could be considered a valuable method for exploring funding policies. Scott (1990) suggests that official documents are neither impartial nor autonomous but in fact they form a vital part of the policy and administration of the organisation's life. Thus, the annual reports and their production offer a relatively impersonal account of an entity which is first and foremost relational in its nature.

7.4.2 Document analysis method limitations

Denzin & Lincoln (1998) describe written records as mute evidence which enables the researcher access to traces of the past, which cannot be questioned directly. However, they can be subjected to interpretive processes and analysis that can help to reconstruct that past, and reconceptualise it in the present. In this respect, the funding bodies' annual reports represent, in effect, social events. Prior (2003) argues that the accounts of social events are always distorted, depending on the sincerity of the observer and their point of view. The distortion comes from the point of view of the observer and how they judge one thing to be worth accounting whilst others are deemed not worthy of being noted. The validity of the analysis comes from the researcher's interpretative ability and skill in conveying their interpretations and by reflecting how the internal meaning from the analysis corresponds with received meaning constructed by the audience it relates to (Scott, 1990). The process of interpretation and the depth of analysis depend on the researcher's interaction and involvement with the documents (Altheide, 1996). Fundamentally, in this context the aim is to explore what the document is referring to rather than focusing on the meaning of a word or a sentence within the document (Prior, 2003).

May (2001, p. 198) highlighted two main critiques of documentary analysis; ‘the bias of documents and selectivity in their analysis’. The former is a warning against taking a document at its face value, and the latter is a caution not to read into a document what one might want to see, with the risk of failing to take into consideration the processes that may have produced the document. The challenge of analysing data out of context is a real one, and sensitivity to that issue is required during interpretation (Appleton & Cowley, 1997). In this study for example, limited details were provided about certain events, context or people’s backgrounds. To address this issue, and for the analysis to be meaningful, the context of the included documents was considered, by referring to other sources to clarify certain issues of interest. In this regard, understanding the intended content of the document; who the author was and the purpose of writing the document, and on the received content of the document, that was, the meaning of the text as conceived by the reader (Scott, 1990). However, it was not always possible to find other documents or resources that could explain some of the context in which certain events occurred. Despite its limitations, document analysis is considered a valid primary research methodology (May, 2001; McCulloch, 2004; Mogalakwe, 2009; Scott, 1990).

7.4.2.1 The study period

As indicated by the bibliometric study, the OE and the PHE started to diverge in terms of estimated numbers of publications and researchers, in the mid-1980s. This change was the primary reason behind the decision to explore funding issues during the period 1980-1995, which also covered a few years before and after the differences had started to appear. Thus, this time was an ideal period to study, in which exploration of the funding issues that contributed to the current challenges and facilitators of OE could be undertaken.

7.4.2.2 Sources

To be able to decide on the sources of the documents, a review of funding sources for OE and PHE studies published during 1980-1994 was conducted. There were a total of 311 publications; 262 in PHE and 49 in OE. From those, funding information was available for 190 studies. The Medical Research Council (MRC), and the Cancer Research Campaign (CRC, currently known as Cancer Research UK) funded the highest number of studies; by supporting 56 ($\mu = 29.5\%$) studies each, either fully or partially. They also shared funding in some of these studies. The second highest funding body was the Imperial Cancer Research Fund (ICRF, merged with CRC to form Cancer Research UK), which supported partially or fully a total of 28 ($\mu = 14.7\%$) studies (some of the studies funds were shared with MRC, CRC or both). The HSE was the operating arm of the Health and Safety Commission (HSC)

during the study period. Both bodies merged in 2008 to become the HSE, which supported partially or fully a total of 7 studies ($\mu = 3.7\%$).

Although ICRF carried out research studies, it did not grant external funding, so it was not considered for review. Unlike CRC and MRC, which are grant-giving bodies, ICRF not only funded less studies, as found in the bibliometric analysis, but it also supported in-house research only; it built its own laboratories and clinical units, and employed its own researchers and scientists (Austoker, 1988; Nurse, 1998).

In this sample, the HSE funded small number of studies. The impression from the OE researchers interviewed and surveyed in the first two phases of the study was that the HSE was considered a key funding body for OE, but that its support to universities had reduced over the years. It was important thus to review the HSE so that this issue could be explored further. Another reason for HSE inclusion was that its relevance to occupational health and thus OE. HSE is the government body that regulates health and safety at work in the UK and also support research in this area. Thus, a great deal of information and insights could be gained, which allows us to understand the challenges to and facilitators of OE in terms of funding related issues.

These funding bodies were then contacted by email with an explanation of the study and its aims, and seeking their advice on the best possible documents they have that could address the study aims. In response, the MRC recommended the annual reports, and a history book about MRC, which was about the period before 1970, and thus was not useful for this study. The CRC and HSE did not provide specific resources and advise to check their websites.

The annual reports published by each funding body represented the policies, mission statements and corporate objectives/plans, and their funding activities and rationales for any new or changes in funding schemes or policies. They do therefore provide a detailed description of each funding body's approach to the allocation of funds. Furthermore, annual reports followed somewhat similar structures, which allowed for inter-funder comparison to be made. In terms of accessibility, the annual reports were available at the British Library as public documents and this facilitated access. Hence, the decision was to review the annual reports of the MRC, CRC, and HSC as the primary data sources (Appendix D-1). However, other resources were referred to when further explanations or understanding of certain events context was needed. These documents were not coded as only small parts were relevant and included during the final stages of the data analysis.

In summary, the three organisations chosen in this review represented the three main funding bodies identified in the previous phases as important, a mix of governmental, charity and disease specific funding institutions. The MRC is the main funding body of biomedical research in the UK. The CRC has been the primary and the biggest single charity source of funding for cancer research in the UK, and the HSC is perceived as being one of the key funding sources for occupational health research, even though the bibliometric study showed that it was responsible for funding fewer studies than expected in the field of cancer. Thus, it was important to analyse its annual reports to gain better understanding of this lack of funding towards OE studies in this field, and whether other areas in OE or in other health research disciplines were facing similar issues.

7.4.2.3 Documents appraisal

Trustworthiness is an important concept as the data collected by the research method needs to provide a true picture of what is being studied. A valid statement gives a true measurement or description of what it claims to measure or describe and an accurate reflection of social reality. In working with archival materials it is important to examine the authenticity of the document and appraise the accuracy, worth and credibility of the data contained within (Mcculloch, 2004; Scott, 1990). Documents are highly biased and selective; they were not compiled for research purposes, but written for different purposes and audiences (Mcculloch, 2004; Scott, 1990). For example, annual reports written by the MRC, CRC and HSC were specific to the running and development of each organisation, therefore were constructs of each body's key specific individuals (e.g., chairmen, secretaries, and key scientists), and scientific and governing boards or committees. This presents an element of bias into the construction of these documents, as the motives and accounts of funding policies and decisions documented on the annual reports are of those individuals and largely not of those who are affected by these decisions. Hence, in appraising the genuineness of written sources it is necessary to question the context in which the document was written and the original intention and purposes of the document. Likewise it is important to consider authors of the document, their interests and positions (Mcculloch, 2004). By doing so, it is possible to understand the biases which may have been introduced into the construction of the document.

In the documents included in this study, the authors, the place and publication dates were established and verified. In order to account for the reliability of a document it is important to ascertain how far the account can be relied upon (Mcculloch, 2004; Scott, 1990). This point is true of the activities, events and financial accounts documented by authors of the annual reports; however, the veracity of funding motives documented (or not documented)

on these events is questionable. Documents are interpretations of events rather than objective accounts (Bailey, 1994). It is important to pay attention to the viewpoint, and knowledge-base of these authors, and consider how their own views may be construed as a bias in the construction of these documents. For example, chairmen of the MRC were appointed by the government not based on their scientific background, but on political and economic grounds. Thus, their agenda may have been closely linked to the government agenda of medical research. This has implications for the credibility of motives stated on funding certain programmes, researchers and organisations.

The credibility of funding motives and decisions documented on the annual reports is also compromised by the level of detail recorded. Bailey (1994) argued that a selective interpretation by the writer may mean that they may present an incomplete record of the situation. The annual reports detailed variable details of the process of establishing new funding policies, appointments of new leaders, or closing down and opening new units of research; some included more details than others or varied from year to another. Sometimes there was no more than a few sentences describing these motives, and thus some important issues may have been missed due to lack of details (such as who influenced these decisions, what happened behind closed doors or during meetings, was there any external influences, etc.). It is also worth noting that the structure, layout and length of the annual reports had changed over the years, depending on the newly appointed individuals who authored these reports (e.g., chairmen, secretaries, key scientists).

The discussions above show that motives for funding policies and funding certain fields, programmes, individuals or units documented on the annual reports may have been biased. This is not to say that the motives for funding issues recorded on these reports are not a valid source of data. Understanding the biases involved in constructing documents '*gives the researcher a significant clue to the issues being studied*' (McCulloch, 2004, p. 43). The documents included in this study provide important details of the internal and external events, policies, and funding circumstances, and insights to how wider factors, such as how political, social, and economic circumstances at that time impacted on funding bodies' decisions and policies.

Despite the limitations and gaps in data as discussed above, the methodological approach, design and data collection were still considered to be robust. Nevertheless, it would be important for future research to validate and strengthen findings from this PhD by analysis further annual reports and interviewing key individuals and then corroborating the themes

uncovered from documentary data and data from other phases of this research. More generally, several additional measures have been taken to maximise the validity of this research (Johnson, 1997). Some of these strategies include the researcher as a ‘detective’; by the researcher taking on the role as a detective, they are able to search for evidence about the effects and causes (Johnson, 1997, p. 283). In the case of this study, there was a search for evidences of factors that influence policies and practice of funding bodies such as changing leadership, social, political, and economic factors. There was also a search for evidences on how funding research disciplines, and consequently their development may have been shaped by changing contexts. In this regard, reference to other documents was sought to uncover certain contexts around certain events and individuals documented in the annual reports, but not fully understood.

7.4.3 Data analysis

There are a range of qualitative and quantitative analytic strategies available for documentary review (Miller & Alvarado, 2005). In this study, both strategies were utilised and discussed below.

7.4.3.1 Statistical analysis

The documents included in this study contained data that required quantitative analysis. This included details of finance such as income and expenditure, and the amount of funds allocated to certain research areas. Simple descriptive statistics were used including means for continuous variables, and frequencies and percentages for categorical variables. Data was extracted using Microsoft Excel, which allowed visual presentation and categorising the relevant data and numbers in a way that facilitated trends and statistical analysis.

7.4.3.2 Framework analysis

The information within each document included in this study varies considerably, therefore, deductive and inductive approaches to the analysis were adopted, using a thematic analysis approach based on framework analysis (FA). FA allows for qualitative data to be examined using a pre-determined set of themes developed from sources external to the data under review. In the process of analysis, this might be amended if any of the new data challenge the pre-existing framework.

The Framework Method belongs to a broad family of thematic analysis or qualitative content analysis (Gale, Heath, Cameron, Rashid, & Redwood, 2013). These approaches identify similarities and differences in qualitative data, before focusing on relationships between different parts of the data, thus seeking to draw descriptive and/or explanatory conclusions grouped around themes (Ritchie & Lewis, 2003).

FA is a matrix-based method of analysis which was developed by the National Centre for Social Research in the 1980s as a policy and practice orientated analytic tool. Referring to the work of Miles and Huberman (1994), Ritchie & Lewis (2003) argued that the main advantage of FA is that it provides the researcher with a structure to systematically work through all analytical tasks (from the raw data to the abstract level) and which allows them to stay close to the original data at all stages during that process.

According to Green & Thorogood (2013), the FA and the grounded theory approaches have much in common, but the main difference between the two is that of the approach used to code data. FA actively seeks to maintain the integrity of individual accounts, and direct access to those accounts within the context of the whole document, throughout the analysis. Grounded theory on the other hand deliberately splits up the data to open it up to new ways of thinking about it. The choice of FA was also motivated by a need to stay as close to the original data as possible; to be able to see the individual cases (each funding body) across all themes, but have access to a comprehensive view of that data at the same time. The flexibility of FA in that it allows both the use of themes emerged in the previous phases as well as new themes from the data.

Document analysis is a time consuming process, in particular since the documents were lengthy (approximately 1500 pages in total in the case of the annual reports for this study) and not written for the purpose of research. Using FA allowed for a focus on the specific information required in order to allow comparisons. The themes chosen to structure the FA for this phase of the study were identified as being particularly relevant to the research question based on the literature review and the previous phases of the study.

Silverman suggested limiting the data set and then conducting a detailed analysis of that data set (Silverman, 2006). This approach goes beyond mere categorisation itself and hence was adopted in this study.

7.4.3.3 Data analysis process

The method used in analysing the documents was informed by the principles described by Ritchie & Lewis, (2003) including;

- data familiarisation and management
- identification of concepts and themes
- charting
- data synthesis and interpretation

Data familiarisation and management

The first stage started when the documents were collected from the British Library. Initially samples of annual reports of each funding body were examined for familiarisation of the structure, layout and content of these documents. Additionally, the documents were examined for usefulness to this research, and whether they contained rich information. This process allowed determining the sections of the documents that were relevant and those that were not. For example; the sections about fundraising activities in the CRC annual reports, the scientific reports that only focused on diseases/conditions in the MRC annual reports, and the details of inspection activities in the HSC annual reports were excluded. The relevant pages were scanned and a file for each document category was created (e.g., MRC AR 1980, CRC AR 1980, HSE AR 1980). After examining and coding (discussed below) the sample documents, another round of data collection from the British Library was carried out for completed document assessment and collection. During this stage, initial thoughts, possible coding scheme and themes to be explored at the next stage were documented.

After completing the data collection stage, quantitative data were extracted and statistically analysed. This process was very time-consuming because there were some discrepancies and gaps in reporting some issues. For example, the MRC reported their funding details for 52 disease areas until the year 1992. These were grouped into nine relevant areas to facilitate analysis. However, after 1992 the MRC grouped these into seven areas but did not clarify which areas (out of the 52) are grouped together, they also omitted (by merging them with others) some areas that are of interest in this study (e.g., environmental studies).

Each document was read thoroughly and initial impressions and thoughts were annotated. Familiarisation through reading and making notes in this way facilitated easier and quicker access to relevant sections around hundreds of pages of documents during the analysis. The documents were then imported into the MAXQDA10 software package. This package was used to help manage, tag, and prepare synthesised summaries of the interview data for later graphical display in Microsoft Excel, which was used to support the later descriptive and interpretative analytic stages. A number of software computer assisted qualitative data analysis (CAQDAS) packages have been developed over the years, each with different types of functions (Ritchie & Lewis, 2003). The main advantage of CAQDAS is that they provide efficient means of managing data, by speeding up the process of locating and retrieving it. They can also support the development of coding schedules and conceptual frameworks (Morse & Richards, 2002). While there is general enthusiasm for the use of CAQDAS, there is also some concern that it generates the impression that it is possible to

put the data through a computer programme for the analysis, and therefore it is crucial to make explicit the analytic processing that can only be done by the researcher (Bringer, Johnston, & Brackenridge, 2006).

Although MAXQDA10 is a powerful qualitative data analysis software, it has some limitations such as handling scanned large data sets. The documents were scanned and saved as images, which means that it is not possible to carry out text search. Furthermore, dealing with the images rather than text, does not allow flexibility in coding and categorising of the text, as well as, viewing the coded segments. Although, MAXQDA10 facilitated the coding process initially, and helped in the process of identifying patterns and key themes, it did not particularly help in visualisation of the coded text resulting in a complicated and tedious task of data analysis, final refinement and summarising results. Tools that are capable of converting images into a searchable text file are available but none of these tools were able to produce clear and accurate results. After several trials, I decided to manually type the text of all the documents into word files, and re-code the text using MAXQDA10. Although it was a time-consuming procedure, it was a better way to handle, code, and analyse large sets of data.

Identification of concepts and themes

Coding data depends on, to some degree, whether the themes are more data driven, by which case the themes depend on the data (inductive approach), or theory driven (deductive approach), where one can approach the data with a question in mind based on relevant literature or previous studies' findings (e.g., have research studies that employ molecular or genetic techniques received more funding than other types of studies?) (Saldaña, 2009). A priori framework was created for this study based on the previous phases of this research (Appendix 1-D). It consisted of the following themes:

- Key researchers influence
- Policy issues
- Collaboration
- Technological and scientific development
- New methods-molecular and genetic techniques
- Financial issues
- Epidemiology/Occupational Epidemiology
- Career structure
- Funding bodies' characteristics
- Other issues

The findings section will show how these were justified and/or amended by the actual data. The entire documents were reviewed systematically to identify any interesting and relevant aspects in relation to the study research questions. Coding continued to be developed and defined throughout the entire analysis.

During this early familiarisation stage, when documents were still in their scanned image format, interesting segments of text were underlined to describe the content of each passage with a code. This could range from only a few words, to parts of sentences or whole paragraphs. To record notes and ideas, the comment tool attached to each code, in MAXQDA10, was utilised; for example questions to bear in mind as the analysis proceeded, and ideas for explanations or patterns in the data. Consequently, a coding framework was drawn up using these data, and themes emerged in the previous phases of the study (Ritchie & Lewis, 2003). The key framework is presented in Appendix 1-D.

Concepts and themes were identified during the intense reading and coding of the documents; a number of questions were asked (Silverman, 2006) while considering the data. These included questions like:

- why this piece of data is interesting?
- what is going on here?
- what are the ideological assumptions in this piece of narrative?
- who is saying this, and why might they be saying it?
- is this data and the issue it appears to represent, similar or different to that found in other documents?
- does this piece of data appear to contradict what was said earlier in this document?

At the same time, concepts and ideas that emerged during the previous phases of the study were also considered during this process (e.g., collaboration and the use of cutting edge methods and techniques). The technique of memoing (Denzin & Lincoln, 2011) was used to capture thoughts about the codes and responses to those questions where appropriate.

Throughout this process the analytical framework was refined and any new codes were added. A brief explanatory description of each category and some codes were added to facilitate some consistency of coding process (see Appendix 1-D).

Charting

Once all the data had been coded using the analytical framework, the data was summarised in a matrix for each theme using Microsoft Excel. The matrix comprised of one row per annual report and one column per code. A separate sheet was used for each category. Subsequently, data was retrieved from documents for each funding body and code; including the memos and comments, and inserted it into the corresponding cell in the matrix. MAXQDA10 was invaluable at this stage, as it allowed for quick and easy retrieval of indexed data for specific codes and categories and the corresponding comments and memos. Summaries of relevant coded texts were also added at this stage if not addressed in the comments and memos sections.

Data synthesis and interpretation

Themes (see section 6.1.4.3.2) were generated from the data set by reviewing the matrix and making connections within and between documents and categories. This process was influenced both by the original research objectives and by new concepts generated inductively from the data. Analytical memoing was used in this process for the development of themes which offered possible explanations for what was happening within the data.

7.5 Results

This section presents the findings from the documentary analysis phase. The findings associated with each aspect of this analysis are presented as follows:

- Characteristics of funding bodies, including descriptions of their annual reports, their organisational structures and purposes, as well as, their income and expenditure;
- Themes emerged in relation to issues that influenced funding decisions.

The chapter concludes with a summary of the main findings. The findings of all study phases will be synthesised and analysed in Chapter 8.

7.5.1 Funding bodies characteristics

To understand the funding mechanisms of each body, the types of funding within each funding body is initially described, and then the issues that influence how funds are allocated are explored.

7.5.1.1 The annual reports

The annual reports were produced to reflect what had happened during the past year in terms of research progress and funding issues. They generally included four core items:

- The chairman’s statement, which provided a general overview of the bodies activities over the previous year, highlighted important events, summarised latest news and any new establishments.
- The Chief Executive’s (or Secretary’s) statements, which highlighted, in more detail, the funding bodies’ activities during the past year and future plans;
- Financial statements, including financial details, and tables of income and expenditure accounts
- Highlights of scientific activities (and/or general activities) and achievements

The lengths of the annual reports varied over the years. The average length of the MRC reports is 70 pages. The CRC reports average length is 100 pages until 1990 then became 20 pages after that. This was because the CRC decided to publish their scientific work in a separate publication called the “Scientific Yearbook”. The Director General DG at that time, David de Peyer, justified this change by saying: ‘*As work increases it has been less satisfactory, and more expensive, to attempt to meet the needs of different groups in one publication*’ (CRC AR, 1991 p4). Finally, the length of the HSC annual reports averaged 100 pages (between 40-160 pages). The number of pages increased over the years because it encompassed more statistics related to health and safety.

7.5.1.2 Medical Research Council (MRC)

MRC Total income

The source of income for the MRC is primarily from the government as a form of grant allocated by the Government's Science Budget; usually referred to as grant-in-aid. The remaining income is from other Government Departments, the commercialisation of research and other research funders (e.g., NHS, research councils, charities, industry and private fund). Figure 7-1 shows MRC income trend in real terms, not adjusted for inflation.

In 1981 the percentage of income from other sources dropped significantly from 21.7% in 1980 to 4.7%, and it continued to fluctuate between 5%-10% over the years (Figure 7-1). The percentage of income in the years 1976 to 1980 (not shown here) was approximately 24% on average. On the other hand, the government grant to the MRC increased from 78.3% to 95.3%, similar income from other sources, had been constant in the previous years with an average of 76% of the total income. The reason for this was the change in funding arrangements with the Department of Health, which contributed approximately 75% of other income sources. The new arrangement allowed the MRC to obtain the funds that were usually commissioned by the Department of Health, directly from its allocated grants.

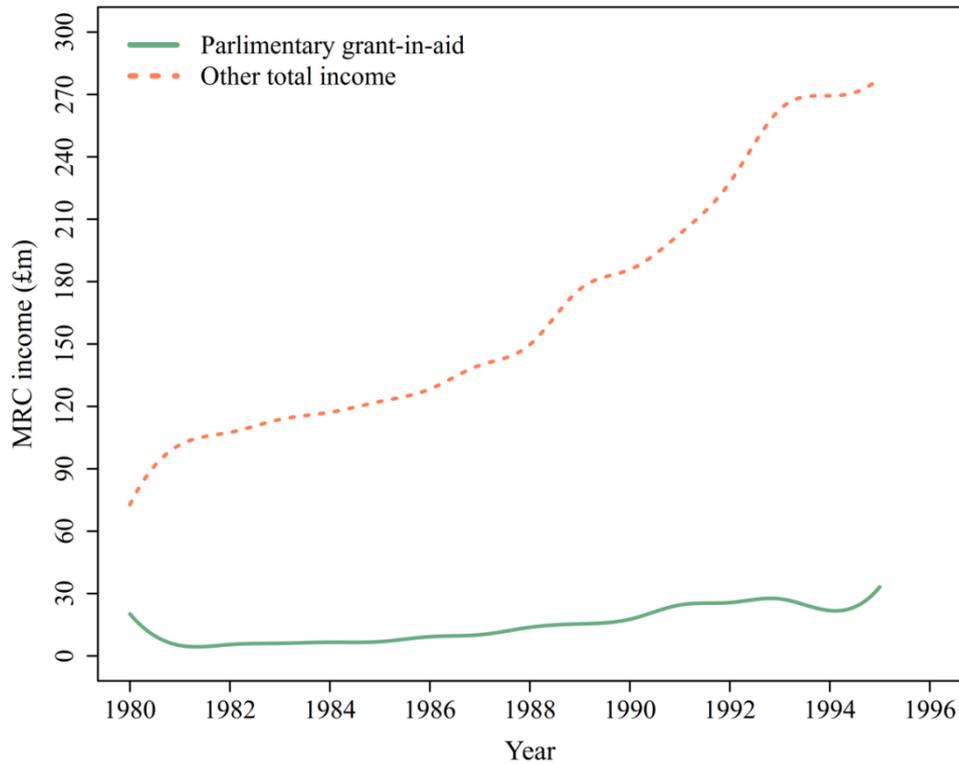


Figure 7-1: Temporal trend of the MRC income (Parliamentary grant-in-aid and other total income).

MRC Direct and Indirect funds

There were two MRC funding systems recognised during the study period; direct and indirect funds. The direct fund mechanism was used when the MRC decided that there was a need to address specific scientific issues and health needs that stand-alone grants were insufficient to address, which included:

- Institutes- includes multidisciplinary research, and the availability of flexible and long-term funds (e.g., National Institute for Medical Research).
- Units- established to support a particular scientific/health need, for which funds were available as long as needed. Thus this could be classified as intermediate-term (approximately 15 years) (e.g., MRC Environmental Epidemiology Unit).
- Centres- established to add value and help establish a centre of excellence. Could be either within MRC remit or jointly between MRC and Universities (Clinical Research Centre; changed to Clinical Sciences Centre in 1995).

The above establishments were subject to review (every five years), where the MRC reviewed their scientific progress. If the establishment passed the review, and ranked

highly, then the MRC continued to support them. Otherwise, the MRC disbanded them and closed them down, or integrated them into other Units or Centres.

During the selected study period, the MRC had reviewed and evaluated several units' performance and activities to decide whether to continue, expand or close down certain units for example:

- the MRC closed down the Pneumoconiosis Unit in 1985, when Dr P C Elmes, the director of the unit from 1976-1982 retired in 1982 (MRC annual report, 1984/85),
- the MRC Environment Physiology Unit, London School of Hygiene and Tropical Medicine (Director: Professor J S Weiner) was disbanded on 30th September 1980, and
- a new MRC Unit on Mechanisms in Tumour Immunity (Director: Professor P J Lachmann) was set up in 1981.

The MRC indirect funding scheme is directed primarily towards research programmes and project grants awarded to Universities; including research grants, training, and fellowships. MRC expenditure on direct research (i.e., Institutes, Centres, and Units) had been slightly higher until 1992. Since then, research programmes and grants to universities have received more funds, which in 1995 was 58.9% compared to 41.1% allocated to direct research (Figure 7-2).

The reason for this shift was because in 1991, the Secretary of State for Education and Science confirmed that from the beginning of the academic year 1992/93 the Research Councils would become responsible for meeting all the costs of the research they supported in Higher Education Institutions (HEIs) apart from academic salaries and premises costs. This change had led to transfer of funds from the Universities Funding Council (UFC) to the Research Councils. The Council has given a firm commitment that all the funds transferred from the UFC will be allocated to support work in HEIs.

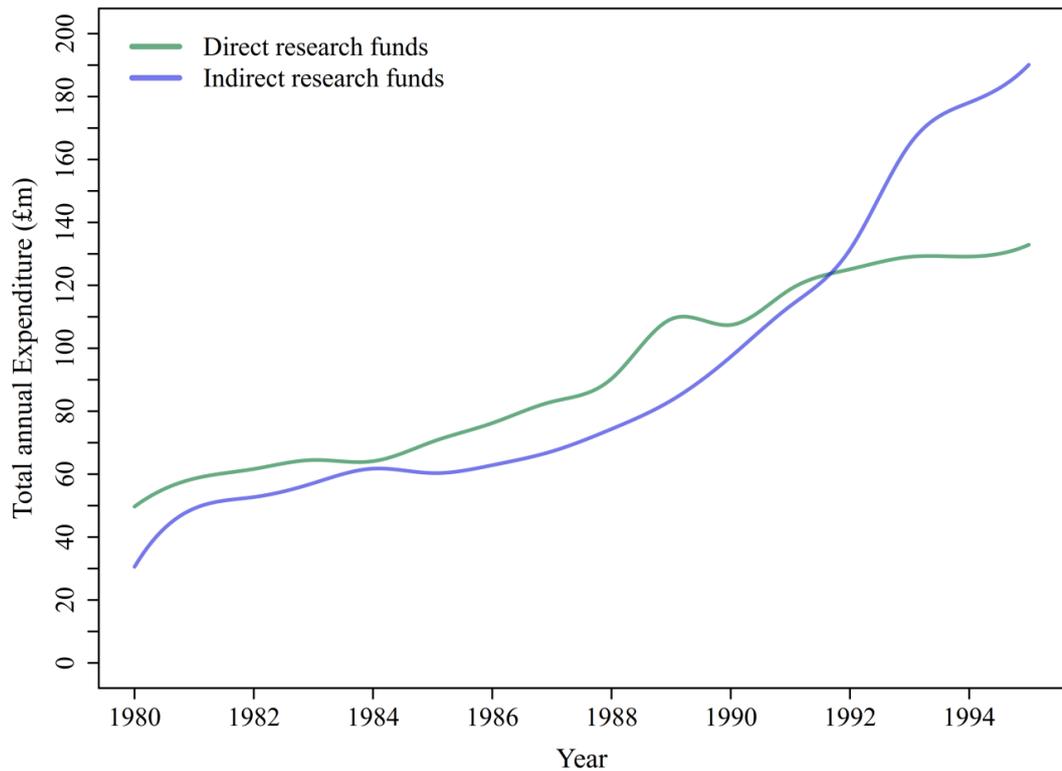


Figure 7-2: MRC research expenditure from 1980 – 1995.

Research areas funded by MRC

There were 52 areas (Appendix D-3) that the MRC had specifically classified and provided funds for during the study period. Some areas were clearly grouped into one theme (e.g., Environment, infectious diseases, and cancer). Other areas were listed implicitly together so that they logically belong to a specific topic (e.g., body systems, and Central Nervous System {CNS}). It was then possible to group the research areas into 9 topics to facilitate analysis. Since 1993 the MRC classified those into 7 topics without any indication exactly what areas of research each topic included. Thus, it was only possible to present the MRC funding trends from 1980 until 1992.

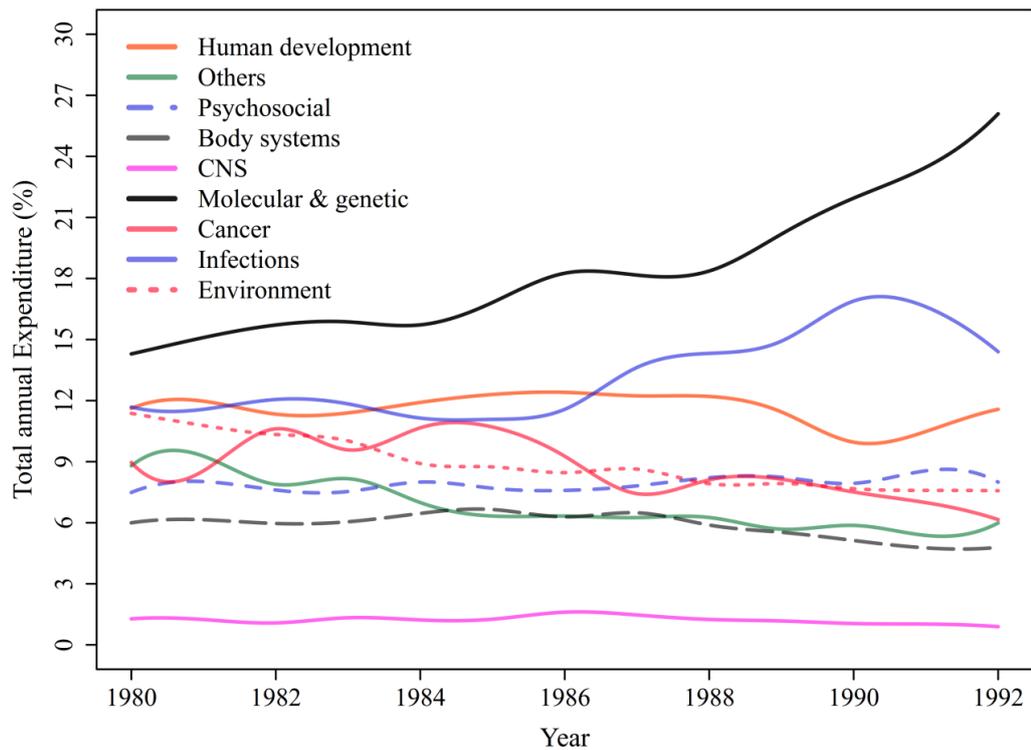


Figure 7-3: MRC funding trend of different research areas.

The temporal trend in the MRC funding from 1980 to 1992 is given in Figure (7-3). The data shows an increasing interest in funding molecular and genetics research. Infectious diseases also received increasing funding due to the internationally based MRC, Tropical Research Councils and the AIDS Directed Programme (ADP) since 1986, and the decline in funding after 1991 represents the ending of the AIDS programme.

The overall funding for Environment (which included epidemiological in general and excluded cancer epidemiology as it was included in Cancer category projects) decreased slightly over the years from 11.3% in 1980 to 7.5% in 1992 (Figure 7-3). However, many of these projects operated in the shadow of much larger programmes, making it difficult to propose new initiatives and garner additional funding for longstanding programmes; such as ADP or Human Genome Mapping Programme (HGMP). For example some major initiatives and programme; such as health service research, ADP, included relevant epidemiological studies:

'The Council has undertaken to increase its own involvement in health services research, a field in which a number of its Units are already undertaking work—for example, in medical sociology, social psychiatry, and epidemiology and medical care' (MRC Annual Report 1981/82).

'The AIDS Directed Programme (concerned with vaccines and drugs) was allocated £5.0m. In addition, £2 was made available for the Strategic

Programme (largely involving epidemiology research). This latter programme was funded in equal measure by the Health Departments and by Council itself.' (MRC Annual Report 1988/89).

'The principal aims of the epidemiology component of the AIDS work are to document the extent and course of the epidemic of HIV infection and AIDS, to establish the determinants of transmission of HIV infection, and to identify the factors which influence progression to disease.' (MRC Annual Report 1989/90).

7.5.1.3 Cancer Research Council (CRC)

CRC background

The British Empire Cancer Campaign, an independent cancer research charity, was founded in 1923 to defeat the disease of cancer, investigate its causes, distribution, symptoms, pathology and treatment and to promote its cure (Austoker, 1988). In 1963, the term '*for Research*' was added to the Campaign's title, to strengthen its legal position with regard to uncertainly worded legacies to '*cancer research*'. However, this title was found to be practically burdensome for everyday use and the words '*British Empire*' tended to cause confusion with the word '*Imperial*' in the minds of the public, particularly due to the name of its rival charity at that time; Imperial Cancer Research Fund (ICRF) (Austoker, 1988). Thus, the title Cancer Research Campaign was adopted in 1970. In February 2002, the CRC and the ICRF merged to form the current world largest cancer research charity known as the Cancer Research UK.

CRC income and expenditure

The CRC expenditure on cancer research in the UK has steadily increased in real terms over the study period 1980-1992 (Figure 7-5). Despite the recession during the 1980s its income had increased (Figure 7-4) and so had its expenditure on research. Its expenditure also exceeded the MRC on cancer research (Figure 7-5).

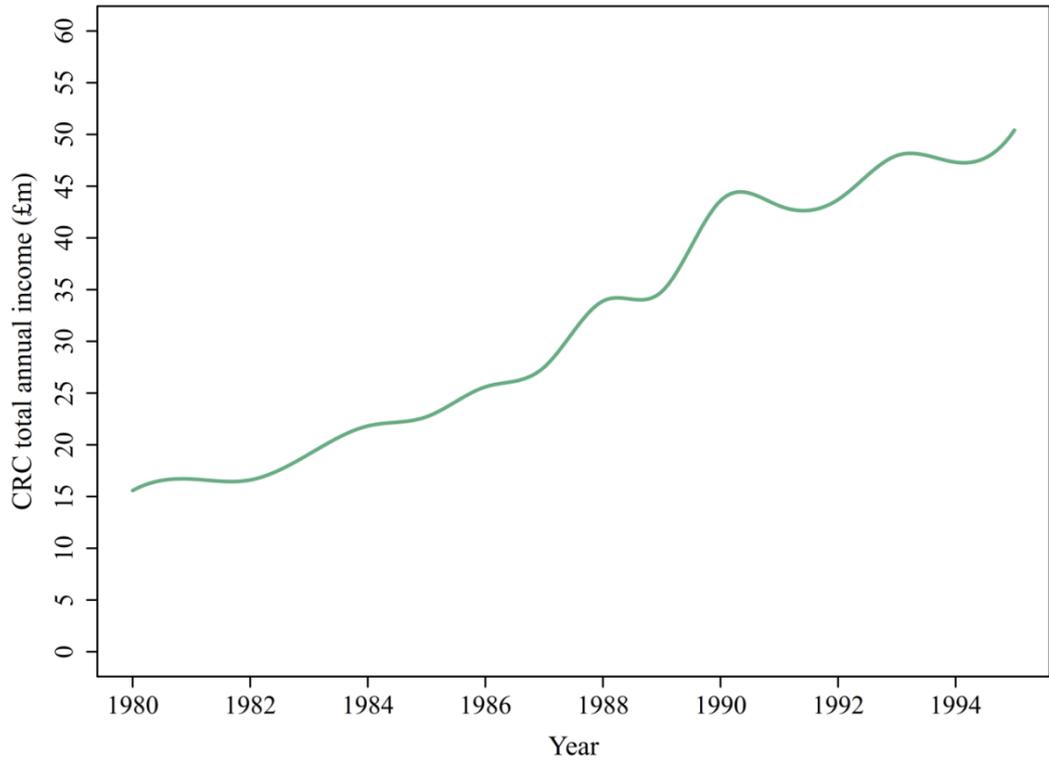


Figure 7-4: CRC income during 1980-1995.

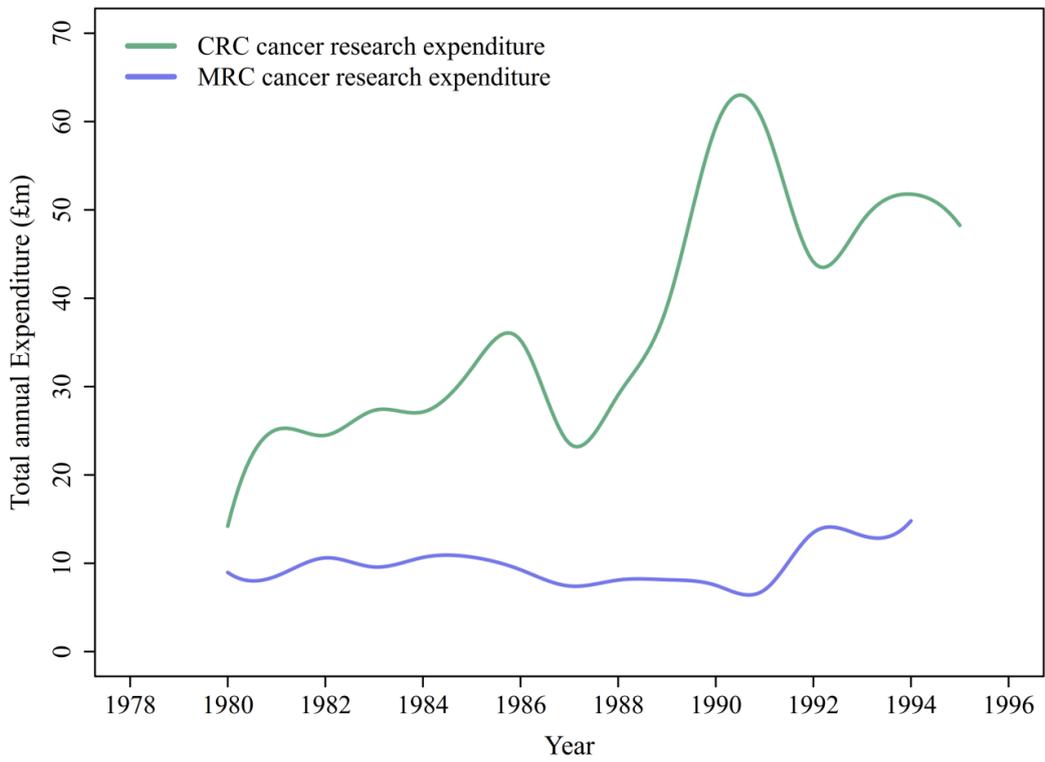


Figure 7-5: CRC expenditure on cancer research compared with MRC.

Due to the financial difficulties experienced by the MRC, there was an agreement between MRC and CRC whereby, over ten-year period starting from 1987, the campaign progressively would take over the MRC's share of funding the Institute of Cancer Research. This reduced the MRC's expenditure on cancer research (as shown on Figure 7-5) by approximately £3 million.

7.5.1.4 Health and Safety Commission (HSC)

The HSC was established in 1974 to implement the Health and Safety at Work etc. Act 1974 (Health and Safety at Work etc. Act 1974). The responsibility of the HSC as outlined in the Act was:

'taking appropriate steps to secure the health, safety and welfare of people at work, to protect the public generally against risks to health and safety arising out of the work situation, to give general direction to the Health and Safety Executive (HSE) and guidance to Local Authorities on the enforcement provisions of the Act, to assist and encourage persons with duties under the Act and to make suitable arrangements for research and the provision of information' (HSC AR, 1974).

Commissioning and conducting research had been one of the responsibilities of HSC. Expenditure on research was around 20-25% of its total expenditure during the period of the documentary review. Approximately 40% of its research expenditure was consistently on nuclear safety. It was not possible to quantify the amount of funding spent on epidemiological research because details about this were not provided. However, relative to the total research expenditure, the fund was not substantial.



Figure 7-6: HSC expenditure on research, testing and agency service.

In 1990, the HSC took over from the Department of Energy the sponsorship role for nuclear safety research programme. As a result, the resources (i.e., the staff already engaged on it in the Department of Transport and the Department of Energy) were transferred to the HSC, which explained the sharp increase of research expenditure in 1990 (Figure 7-6).

7.5.2 Issues influenced funding decisions

One of the main objectives of this study is to explore issues that influenced the decisions of funding bodies to support certain studies or fields, as well as, issues that could discourage funding bodies to support particular studies or fields. The codes and themes emerging from the documentary data revealed that there were five key interwoven themes that could explain how funding was allocated and on what basis. See Appendix D-2 for the full account of the coding process. As can be seen, there were five core themes:

- 1- The influence of key leaders and/or researchers in positions of power or leadership.
- 2- The influence of internal and external policies.
- 3- Collaboration.
- 4- Technological development and evolution of new methods and techniques.
- 5- Funding issues related to epidemiological studies.

All of these themes were already included in the framework analysis (FA) structure at the beginning of the data analysis process (section 6.1.4.3.2). All of these were also reinforced by the documentary data; however two themes were modified as follows:

- The theme ‘the influence of key researchers’ was modified to ‘the influence of key leaders and researcher in positions of power’. The data showed that not only key researchers influence the funding decisions, but also other key leaders in the funding bodies, such as the chairmen or other administrators or managers. The chairmen were not usually scientists or researchers, but individuals who possessed political, economic, or social power, or any combination of these.
- The theme ‘the use of new methods and techniques’ was modified to ‘Technological development and evolution of new methods and techniques’. This modification was because the data showed that new methods development was linked to and based upon advances of new technologies. For example, research in molecular and genetic techniques evolved through the development of the technologies used for carrying them out such as DNA Microarray technology.

These five themes are discussed in the following sections.

7.5.2.1 The influence of key leaders and/or researchers in positions of power or leadership

The Council boards and the Scientific Committees in the MRC and CRC reviewed research programmes and projects proposals and decided whether to grant funding or not. They were also responsible for scrutinising the performance and progress of certain research programmes within institutes and universities and deciding whether these programmes or projects merited further support, expansion, or suspension. Besides, they decided on all issues of major importance including issues of corporate strategy, key strategic objectives and targets, and major decisions involving the use of financial and other resources.

Those who influence some of the funding policies were those who are responsible for deciding which research programmes or studies they wish to see in the future. These researchers were usually key researchers and leaders in certain fields. Additionally, some of them were grantees of these funding bodies, which supported their main work. Case studies are presented later to illustrate this point.

Once a new chairman or director in the funding bodies, as well as new head of a particular key unit or institute was appointed, a review of the work funding body of his/her group/institute work was usually completed. The review usually led to new changes and research priorities, which to a great extent reflected the new chairman's or leader's interests. To illustrate this point, key examples and case studies of the effect of leaders and key researchers are discussed next. It is worth noting that this issue was consistent throughout the documents, however, it was necessary to be selective in presenting these and present only the most important examples and cases. Some other case studies are also presented in Appendix D-5.

Variations in leaders' decision-making power across the funding bodies

The influences of key leaders and researchers in positions of power varied across the funding bodies in terms of funding decision-making influence and independence of other factors.

In the MRC, such individuals were directly employed by the government (the chairman and secretary) and others by the relevant MRC boards. They were somehow independent in their decision-making process; however, in terms of general overall funding policy-settings they had always considered the government science and research policies and guidelines.

In the CRC, the key leaders were directly employed by the relevant committees within the CRC. They were also less bounded to governmental policies and influence, and were more independent in their funding decision-making. However, CRC had worked with universities and research institutes that were primarily or partially funded by the government and other charities, and thus key leaders' and researchers' decisions were also, to a lesser extent, influenced by the general government policies and socioeconomic circumstances:

'The number of applications for project grants from the universities and medical schools has increased significantly. This form of short term support can be regarded as the bread and butter of cancer research, inevitably these grants are becoming more difficult to win, at present one in four of the new applications received are recommended for an award. The difficulties universities experiencing are due to the government cut on expenditure.' (CRC AR, 1981).

The statements below also show the power of government policies and how these affected the CRC's funding mechanisms and the way charities operated:

'Last year the Government's White Paper Charities: A Framework for the Future was published. It made over 40 recommendations, most of them concerned with the Charity Commission's powers and responsibilities, though four dealt with malpractices in fund-raising. Some recommendations will

require legislation. The Campaign would warmly support measures to increase the effectiveness of the Commission and to stamp out abuses of the generosity of the public. Like the Woodfield Committee, the Government welcomed the Statement of Recommended Practice Accounting by Charities with which the Campaign has been complying since its introduction in May 1988.' (CRC AR, 1989).

'Earlier scientific reports have commented on the changing environment for medical research in the United Kingdom. In the past year the White Paper 'Working for Patients' has become the 'NHS and Community Care Bill' which outlines fundamental changes to the way the NHS will operate. At the same time the Government has plans to alter the way in which Universities receive the funds necessary to underpin research funded by charities and other bodies.....our concerns are how these wide- ranging changes might adversely affect Campaign-funded research.' (CRC AR, 1989).

The CRC leaders in their part attempted to influence the government funding policies as shown below:

'In earlier Annual Reports I have referred to the implications for the Campaign of changes in Government policy, and particularly the restrictions in Government funding of universities and the MRC. The Campaign is the leading supporter of cancer research in universities and medical schools in the UK, and will be spending over £20m there in 1989 out of the total research budget.... We are therefore bound to be affected by such changes. I recorded last year that proposals in the Report of the Advisory Board for the Research Councils, A Strategy for the Science Base relating to the transfer of responsibility for research overheads, had potentially serious consequences for the Campaign. At its worst, the cost to the Campaign of its present volume of research in universities and medical schools could rise by upwards of £8m per annum. This would inevitably lead to a severe curtailment of our efforts. We brought our anxieties on this score to the attention of Mr Robert Jackson MP, the Minister responsible for science at the Department of Education and Science, when he visited Campaign Headquarters in May last year, and representations have also been made through the Association of Medical Research Charities.....This is another area in which the Campaign will be making representations to Government. The Campaign has always had a close relationship with the Medical Research Council. Both the former Secretary, Sir James Gowans, and Dr D A Rees, his successor, served on our Council and there are many other links, including regular meetings between the two organisations. Two such meetings were held last year and it is intended that they should occur at roughly six-monthly intervals.' (CRC AR, 1988).

Case Studies to illustrate the influence of key Leaders and researchers

Sir Dai Rees

Sir Dai Rees was one of the most influential leaders in the MRC during the study period. Scientifically, he was known for his work on the structure and biochemistry of polysaccharides and the relationship between surface glycoproteins and the cytoskeleton in cell adhesion, shape and motility. He received several awards including the Colworth Medal

of the Biochemical Society in 1970; elected fellow of the Royal Society in 1981; elected honorary Fellow of the Royal College of Physicians in 1986. He was knighted in 1993.

Rees became a member of the MRC Council in 1984, and the secretary of the MRC in 1987. This meant he gained more leadership power and responsibilities of the MRC including strategic research and organisational planning, policy settings, financial management, and decisions about funding priorities. He was the director of Unilever (healthcare and cleaning product company) bioscience research programme before he was invited by the MRC to co-direct the MRC Cell Biophysics Unit at King's College London. This position probably helped him to get to know the MRC and its politics. In 1980, Rees became part of a new sub-committee set up by the MRC to determine the future of the National Institute of Medical Research (NIMR) after Arnold Burgen's departure from his role as the director of the Institute. The committee was established to decide whether the NIMR should continue or close, particularly during the difficult economic climate at that time and the government pressure on MRC and other governmental bodies for financial efficiency. These issues were eloquently explained by Julie Clayton quoting Rees when she interviewed him in 2013:

'The UK government led by Margaret Thatcher was demanding more financial accountability from publicly funded research establishments, and "universities, institutes and MRC units all began fighting their corners," according to Rees. There was a growing resentment from universities over the amount of money spent by MRC on its freestanding Institutes: NIMR, the Laboratory for Molecular Biology (LMB) in Cambridge, and the Clinical Research Centre (CRC) at Northwick Park, Harrow. To Rees it appeared that NIMR scientists were blissfully unaware of these external pressures, or their own potential role in demonstrating value-for-money. The Institute was like "a cocoon - a protected environment where people get on with their science," but without understanding "the relationship they need to have with the outside world." Rees made it his mission to improve this relationship, and so help the Institute to survive in an increasingly competitive world.' (Clayton, 2014, pp. 87–88).

In his role on the sub-committee, Rees suggested the idea of restructuring the Institute as an opportunity to develop a scientific strategy that could put the Institute at forefront of medical sciences development and discoveries. The sub-committee decided to keep the NIMR open and invited Rees to be the Director in 1982. He then embarked on restructuring the Institute by building four larger groups from several smaller groups: Genes and Cellular Controls; Infections and Immunity; Physiological, Neural and Developmental Mechanisms; and the more services-orientated Technology and Management. The main advantages of this structure were that it looked more cohesive, and would help attract new high-level scientists who in turn would develop and strengthen areas of shared interest.

Consequently, Rees appointed new leaders to these four larger groups. He seemed to have personally chosen those leaders in a hope that they would improve research programmes in these areas and position the NIMR at the forefront.

The first appointment was David Trentham for the Physiological, Neural and Developmental Mechanisms Group, and head of the Division of Physical Biochemistry. Trentham was a prominent British researcher at the University of Philadelphia, USA. Trentham was encouraged by Rees to bring new researchers and attract external collaboration and funds. On this subject, Julie Clayton quoted Trentham saying:

‘Throughout my time I always had external support, usually in programme projects with other groups, particularly in America but also in Europe... that was a condition for me coming.’ (Clayton, 2014, p. 91).

One of the key focus areas for Rees was the expansion of developmental biology in order to distinguish the NIMR from the LMB. He, however, acknowledged his personal interest in this area:

‘I’ve always been fascinated by the problem of embryonic development, even though I haven’t worked on it. So I’m sympathetic to those who want to move into that area.’ (Clayton, 2014, p. 91).

He then chose Peter Rigby, a geneticist from Imperial College London to lead this group. Rees had his own group, Cell Surface Interactions, which was part of Rigby larger group. Julie Clayton interviewed Rigby in 2014 and explained the appointment circumstances of Rigby; showing how informal and targeted this appointment was by quoting some of his own words:

‘Starting with drinks at the Athenaeum club, Rees told Rigby: “I want you to make the best developmental biology group in the world.” He did not need much persuading (Rigby). “For the next ten years, we were the best by a mile,” Rigby recalls.’ (Clayton, 2014, p. 91).

Rees encouraged John Skehel, head of the Division of Virology at NIMR, to become head of the Infections and Immunity Group. The fourth group was Technology and Management, led by Gordon Taylor from the same group at NIMR. In January 1986 this was renamed the Technology Institute Group, with Rees as head, following Gordon Taylor’s departure.

Generating profit

Having an industrial background, Rees initiated the idea of industry partnership. It was also recommended by the sub-committee (including Rees), which reviewed the work of NIMR,

that the institute should connect with future exploitation in medical care or in British industry (MRC AR, 1982).

Hence in 1984, Rees established a new centre for collaboration with industry; the MRC Collaborative Centre, and became an interim director. The Centre was located in the same building where the NIMR was, and included offices and laboratories for exploratory work. The Council spent £2 million upgrading and equipping the laboratories. Industry partners provided the finance and took on the commercial development of the most promising products. The Centre was anticipated to be self-financing after five years, generating a minimum of £340,000 per annum. By the end of 1986, Rees won contracts worth £1.2 million. In 1988 the MRC Collaborative Centre became an independently run non-profit company limited. By 1999, there was a surplus income of around £12 million, and some of its projects led to top selling products, such as Humanised antibodies, and this alone profited the MRC around £84m between the years 2000 and 2006 (Clayton, 2014).

Epidemiology research leaders

The majority of the epidemiological projects ($n = 37$; $\mu = 61\%$) funded by CRC during 11 year period (1980-1990) were the projects of three leading researchers.

The first researcher who led 24 projects (40%) was Leo Kinlen from the Radcliffe Infirmary, CRC Cancer Epidemiology Research Group (CERG), Oxford, and was appointed as the director of CRC Cancer Epidemiology Unit, University of Edinburgh in 1982. Kinlen was awarded a life-long fellowship in 1972 by the CRC called the Gibb fellowship, where the work of a researcher was supported during his time at the campaign.

The second researcher who headed 7 projects (11.7%, 1 was jointly with Kinlen) was Julian Peto. He first joined the CRC in 1983 when he was appointed to the Chair of Epidemiology at the Institute of Cancer Research succeeding Michael Alderson who moved to the Office of Population Censuses Surveys.

The third leader was Jillian Birch. She obtained funding for 7 projects (11.7%). She was working in Department of Epidemiology and Social Medicine, University of Manchester under Waterhouse's direction as a postdoctoral researcher. Subsequently she was awarded a five years career development award by the Campaign in 1984. She became the director of the Manchester Children's Tumour Registry. Her work was later reviewed by the CRC in 1989 and the feedback about her work was:

'Dr Birch's work on Wilm's tumours, childhood neural tumours and Li-Fraumeni syndrome was considered excellent. Studies like these yield important information for our understanding of how these tumours develop, but they also provide an important opportunity for counselling families which have a genetic predisposition to these cancer syndromes. As a result of the site visit, funding to Dr Birch was renewed for a further five year period, her own personal support as a CRC Fellow was strengthened and her group renamed as the CRC Paediatric and Familial Cancer Research Group which better describes its activities. Dr Birch will also be working closely with members of the Section of Cancer Genetics in the Paterson Institute on the molecular biology of paediatric tumours with the aim of locating and identifying the genes involved in these disorders.' (CRC, AR, 1989/90)

7.5.2.2 The influence of internal and external policies

The internal policies' of the funding bodies as well as the external policies, such as those developed by the government, had influenced the funding policies and allocations. Consequently, this had an impact on the type of studies and fields that received high or low funds. As a governmental body, the MRC funding policies were more influenced than the CRC. Thus, these issues are discussed in relation to the external and internal policies of the MRC, and primarily the internal policies of the CRC.

It is worth noting that within the HSC, government policies had even higher impact on the policy setting and strategic planning of all aspects of the HSC, and not only on research funding. However, the HSC issues are not discussed in this section because the influence was somehow comparable to that of the MRC.

Policies' influence on the MRC funding decisions: internal and external issues

Two key government policies had significant influences on the MRC funding policies and allocations of funds. These were; the White Paper 'The Health of the Nation' published in July 1992; and White paper "Realising our Potential" published in May 1993. The implications of these two policies are discussed in the following sections.

The 1992 White Paper 'The Health of the Nation'

In March 1991, the MRC published its Corporate Plan for a four year period (1991-1996). The 1990/91 annual report highlighted the main issue in the plan, including the financial difficulties that the MRC was facing, and the decision to constrain research funding. They questioned *'how best to balance the requirements of important new initiative while limiting the damage to those existing activities which continue to be important'* (MRC AR, 1990/91, P7).

The MRC Plan also provided details of the Council's future scientific strategies. Despite the planned cuts, the MRC decided to invest in 'exciting scientific opportunities' in the following areas: the genetic approach to human health; the neurosciences approach to human health; and physiological mechanisms and public health (mainly research in nutrition, the environment, diabetes, and imaging).

Shortly after, the government published the White Paper 'The Health of the Nation' in July 1992 (HMSO, 1992). Five key areas were given priority with specific objectives; coronary heart disease and stroke, cancers, mental illness, accidents, and HIV/AIDS and sexual health. As it appeared from MRC new corporate plan and the government White Paper, the focus shifted to research related to disease prevention and health promotion.

For instant, in 1992, a Concordat was signed between the Overseas Development Administration (ODA) and MRC to provide a new framework for the more effective promotion and management of research in developing countries. The agreement commits the ODA and the MRC to a joint programme of high-quality research into priority health problems of developing countries. These include reproductive health, malaria, AIDS and other sexually transmitted diseases. The ODA aimed to provide a continuing contribution to the MRC's research in these areas, which were emphasised as research priority areas in the White Paper.

Conducting studies that were considered as priority areas was strengthening by collaborating and linking with the relevant health departments. As a result, a new institute was established, the 'Institute for Environment and Health' in collaboration with the Department of Health and Environment. The focus of this institute was on environmental health risks to the general population. A new centre was also established to exploit the advances in genetic and molecular sciences in toxicology; Interdisciplinary Research Centre for Mechanisms of Human Toxicity:

'Thus the MRC now has a presence on the Department of Health's Central Research and Development Committee and key advisory groups such as the Standing Group on Health Technology and its Panels, as well as observers on most of the NHS's Regional R&D Committees. The Council is using these links to develop complementary and collaborative programmes to address research priorities identified in the White Paper The Health of the Nation and by the NHS R&D programme, as well as developing MRC future priorities for clinical trials and research.' (MRC AR, 1992/93).

As a consequence of the White paper, the MRC, in its funding policies and decisions, had to take into account the research needs of other health departments within the government (e.g., the NHS and DH):

'In accordance with the 1992 Concordat between the MRC and the Health Departments, the MRC takes account of Department and NHS needs in developing new strategies and initiatives, and also in decisions on funding of applications, assisted by Health Department members and observers on MRC Boards. Particular stress is being put on carrying forward priority areas identified in the Health of the Nation White Paper.' (MRC AR, 1994/95).

Being a priority area identified by the White Paper, the work of the MRC nutritional programme had further increased, including epidemiological studies in areas related to obesity, heart disease, stroke and cancer:

'A major initiative in public health policy was taken by the Government with the publication of the White Paper The Health of the Nation, It discussed a range of health targets but gave special emphasis to subjects relating to food and nutrition. Significantly, the White Paper not only indicated priorities for health professionals to tackle -it also invited the different sectors of the Food Industry, including food processors, retailers and the catering trades, to help in achieving the dietary and health goals that had been set.....Much of the nutrition research that the MRC funds is directly relevant to The Health of the Nation. Even before the White Paper appeared, the MRC Dunn Nutrition Centre in Cambridge had already established a Consultancy Service to advise companies in the food industry on how best to come to terms with their new responsibilities.....

....The MRC is equally involved in studies on the links between diet and cancer. These are being conducted both at an epidemiological level as well as more mechanistically. Nick Day of the MRC Biostatistics Unit in Cambridge is working with Sheila Bingham of the Dunn on a study on diet, intermediate risks and cancer. This study will follow 75000 individuals in the UK and is part of an even bigger European investigation involving half a million people. The study necessitates close collaboration with a number of other organisations within the European Community. (MRC AR, 1993/94).

The following statement summarises the initiatives and proposals to strengthening research in nutrition as a result of the White Paper:

'The MRC has an active research programme in human nutrition. A new purpose designed building will be erected at New Addenbrookes Hospital, Cambridge to facilitate this policy. The mission will be to explore and define the dietary patterns, at the different stages of life, that best achieve optimal health and wellbeing. Research collaboration with the food industry to ensure a continued improvement in the nutritional quality of the nation's food supplies will be maintained and enhanced, as will more traditional links with Government departments and other research councils and their institutes. University departments undertaking nutritional research, especially within medical schools, will likewise be encouraged' (MRC AR, 1993/94).

Achieving the goals of the policies set out in the White Paper continued to be emphasised in later years:

'Indeed, the MRC has continued to fund and develop research in areas of particular concern to the health departments (including, for example, the

transmissible spongiform encephalopathies) as well as research that will contribute to the priorities identified in the 1992 Health of the Nation White Paper.’ (MRC AR, 1995/96)

The 1993 White paper “Realising our Potential”

Another Corporate Plan and Scientific strategy was published in 1993 for the period 1993-1997 (MRC AR, 1992/93). The production of these documents was three years earlier than expected. The MRC annual report discussing these documents did not provide details of any research priorities, but indicated that they were produced to address management and scientific planning for particular audiences, namely the research community and other bodies interested in research.

Nonetheless, the production of these documents coincided with the government review of science and technology, to which the MRC had contributed, and with the publication of the government White paper “*Realising our Potential*” in May 1993. The research priorities presented in the 1991 Corporate Plan did not change after the production of the 1993 Plan. This indicates that the 1993 Plan was produced as an early response to the government review of science and technology, and the White Paper. In particular, the MRC had already contributed to the review, and their contribution had been acknowledged within the government policies (this issue is discussed further below).

The focus of the White Paper was on partnerships between industry, government and the science base. It encouraged initiatives for improving collaboration and links between universities, industry and government to promote the transfer of technology; greater innovation support to firms; and the promotion of the public understanding of science (*Realising our potential*, 1993):

‘The publication of the White Paper Realising Our Potential in March 1993 laid down a number of challenges for Research Councils. Prominent among these was the requirement to do our utmost to advance knowledge and technology, and provide trained researchers, to meet the needs of industry as well as those of the health providers, so contributing to wealth creation as well as to improvements in the quality of life. It was a requirement that we in the MRC welcomed: fundamental research remains our lifeblood, but we must work to ensure that it is translated into real benefits.’ (MRC AR, 1993/94).

The MRC welcomed both the review and the White Paper recommendations. Indeed, the MRC in addition to updating their Corporate Plan in 1993, the annual report structure was also changed in 1993/94, to reflect each of the initiatives in the “*Realising our Potential*” White Paper. The content of the report was categorised under; support for research, the

financial framework, working with users (universities, industries, and government departments), investing in people, and international and public understanding:

'The White Paper and the new thinking it sparked off is also reflected in this year's Annual Report. As in other areas, it is not "business as usual". The Report has a new structure that is designed to reflect our priorities and the way that we plan and work. Chapters focus on the key areas of our mission: research, users, international cooperation, human resources and public awareness. Each section aims to give an indication of the main thrust of our activity as well as the solid facts of our achievements over the year.' (MRC AR, 1993/94).

Rees stressed the importance of the White Paper and its influence on the structure of science and technology in the UK and particularly within the MRC. He expressed the commitment of the MRC in fulfilling the White Paper's policies, in which he played a major role:

'The entire framework for research in the UK has been remade by the White Paper Realising our Potential, which was published in May 1993. Yet though the directions commended in it are challenging — to say the least — we at the MRC have not found them hard to follow by developing our own thinking and best practice.'

We identify completely with the commitment to maintaining the country's strength in science, engineering and technology and to continuing its excellent record of research in the basic and applied sciences. We share the commitment to investment in training and career development to meet the UK's manpower needs. And we recognise the imperative — it was always implicit in our pre-White Paper mission — to consider the needs of users and to ask ourselves for whom and for what purpose we are supporting research.' (MRC AR, 1994/95).

In the following year after publishing the White Paper, the MRC continued to work on implementing the policies set out in the White Paper. This was evident in the chairman's statement who expressed that there were still few difficulties experienced in implementing the policies, but emphasised that these challenges will be overcome:

'This report covers the first full year following the changes in mission and organisation introduced in the White Paper Realising Our Potential. The new system and structures have taken time to bed down, and doubtless there are one or two rough edges still around. Our Council is now leaner and certainly no less fit..... We now hope for a period of relative stability in which we can focus on our core business of promoting and supporting research relevant to national needs.' (MRC AR, 1994/5).

The MRC then developed several internal policies as a response to the White Paper. This included:

- *'building our links with our user communities;*
- *manpower and training policies, developing the careers of young and more experienced scientists and support staff;*

- *public understanding, where for the first time Research Councils have an explicit duty to promote not simply their own work, but science in general.* (MRC AR, 1994/5).

Similarly the MRC continued to implement the White Paper policies in later years:

'The MRC has continued its efforts - across a range of scientific priorities - to implement the policies set out in the government White Paper for science, Realising Our Potential.' (MRC AR, 1995/96).

A year after implementing the White Paper's policies, the chairman referred to each relevant element of these policies and established how the MRC had achieved the goals of these:

'Our grants and fellowships schemes [provide trained researchers] have been adapted and enlarged to take full account of the White Paper objectives. Our relationship with industry [strengthening links and collaboration with industry] continues to develop. A series of Concordats cover our relationships with key government departments [improving collaboration and links government departments]. We take our responsibilities in public understanding of science seriously [the promotion of the public understanding of science] The year also saw the decision to fund pilot Research Masters programmes, as well as discussions at a number of levels aimed at improving the career management of contract researchers [provide trained researchers].' (MRC AR, 1994/5).

Dai Rees, the then secretary of the MRC had personally supervised the implementation of the White Paper's policies, particularly in relation to commercial exploitation of the MRC research via strengthening the links and collaboration between the MRC, Universities and industry:

'During the year Sir Dai Rees and senior Head Office colleagues visited a number of universities receiving major Council funding to talk to researchers and university officers about delivering objectives arising from the White Paper Realising our Potential. A key aspect of this has been to explore whether closer working between universities and the MRC would aid commercial exploitation of work funded through MRC grants.' (MRC AR, 1994/5).

Providing trained researchers

In response to the requirement of the White Paper 'Realising Our Potential' in relation to providing trained researchers, the MRC reviewed its project grants and training policies and introduced some changes to these policies to improve training and the prospects of research career structure of new researchers:

'The review confirmed the continued commitment to this form of support, but Council has made a number of changes in order to match the scheme more closely to its objectives (also to address some of the issues raised in the White Paper Realising our Potential) for the 1993/4 award year:

- *a more rapid assessment process for, and increased numbers of small grants (up to £25000 for one year) which provide for feasibility studies which may develop into longer-term projects;*
- *infrastructural and equipment grants to improve the environment and the career development of support staff in departments with extensive MRC support;*
- *5-year project grants will be awarded where this will provide explicit continuity and development opportunity for key support staff.’ (MRC AR, 1993/94).*

Furthermore, The MRC had announced a number of new forms of support for the 1993/94 award year including the following:

- *‘new career development awards for high-quality researchers looking to consolidate research experience with a view to a long-term career in research (these are available to clinical and non-clinical scientists and may include provision for experience to be gained in a laboratory overseas);*
- *for established scientists, prestigious awards of MRC Professorships and Readerships, again for clinical and non-clinical staff;*
- *opportunities for part-time awards for clinical or non-clinical scientists wishing to combine research with family commitments and/or returning to science after a career break.’ (MRC AR, 1993/94).*

Relationship with industry and relevant government department

New initiatives were established to achieve the commercial exploitation of the MRC work for example; founding an institute to develop new vaccines by collaborating with industry and DH:

‘In December 1994, the MRC together with Glaxo (now Glaxo Wellcome), the Biotechnology and Biological Sciences Research Council and the Department of Health, launched the Edward Jenner Institute for Vaccine Research, as a new, independent research centre. Its strategic research programme will be directed at novel ways of enhancing the immune response to vaccination and at new routes of delivering vaccines, so providing the basis for industry to develop new vaccines.....This boost for vaccine research will be funded 50: 50 by Glaxo and the public sector participants, to a maximum annual budget of £6 million, in an imaginative response to the White Paper call for new forms of partnership with industry. The MRC will contribute £1.5 million a year. Some of the funding will be used to support collaborative research in universities and other research institutes, to ensure a concerted attack on major health problems’ (MRC AR, 1994/5).

Another example of initiative that aimed at developing new links with industry and other public organisations was also established and mentioned by Rees in the following year:

‘The establishment of the National Technology Foresight programme is particularly welcome, and the MRC as a whole has been actively involved in providing input to the planning process — not only through my own membership of the Technology Foresight Steering Committee, but also via the

MRC scientists who serve on some of the sector panels, and indeed the many members of the MRC community involved in consultations.’ (MRC AR, 1994/5).

The impact of the White Paper was also reflected on the assessment criteria for judging research proposal by focusing on how these proposals meet the MRC strategies particularly in relation to potential for commercialisation. Thus the economic value of research had become a key theme in funding decisions as a result of the White Paper:

‘The MRC judges research proposals on a competitive basis against the same fundamental criteria: scientific quality; contribution to strategy including exploitability and applicability; and value for money. The claims of particular programmes in one field are weighed against the claims of particular programmes in another. Equally, the claims for work in the MRC’s own research institutes and units are weighed against claims for grant support, and vice versa.’ (MRC AR, 1994/5).

The importance of epidemiological studies was also linked to the ability of producing areas for further research using molecular approaches that could lead to relevant products:

‘The breadth of the MRC’s scientific programme is set by our mission. This requires research across the full spectrum of biological and medical sciences to increase our understanding of human biology and behaviour and of the causes and mechanisms of disease and ill-health. Studies of individuals and populations are also essential and can pinpoint productive areas for molecular approaches. Together these contribute to the identification of improved methods of prevention, diagnosis and treatment.’ (MRC AR, 1994/5).

The expansion policy of CRC

The campaign has expanded over the years due to an increase in its income and subsequently has become more powerful in terms of its influence in government policies. It has become a strong player in the field cancer research. During the time when the MRC was suffering income cuts, the CRC was growing and its income has gradually increased. The CRC took this opportunity to expand its activity by taking over funding from MRC to areas that the CRC found important.

For several years, three institutes were jointly supported by the MRC and the Campaign. These were; the Institute of Cancer Research (ICR), the Beatson Institute for Cancer Research in Glasgow and the Paterson Laboratories of the Christie Hospital in Manchester. However, in 1980 the CRC decided to increase its presence in these:

‘In view of the restraint on Government expenditure the Campaign has now undertaken additional responsibility for the funding of the Medical Research Council’s share of the Beatson and the Paterson from April 1981. While the institutes will retain considerable independence the Campaign will provide a

greater measure of stability and exercise closer surveillance over their research programmes. The additional cost to the Campaign, including the revised shared funding arrangements for the Institute of Cancer Research, will amount to about £1m extra a year at 1981 prices.’ (CRC AR, 1980).

The above statement clearly reflects the CRC interest in the institutes. It also shows the interest of the CRC to retain more control by mentoring closely the institutes’ activities and influencing the type of research funded in these institutes.

This interest continued with the increase in CRC income and the MRC financial difficulties. Then in 1985 CRC increased their fund share to the ICR:

‘I referred last year to the increasing pressure on Medical Research Council (MRC) funds. The MRC and the Campaign jointly fund the Institute of Cancer Research, one of the leading cancer research institutes in the country. At the request of the MRC we have agreed to increase to 50% our share of the funding. This will add some £600,000 to the Campaigns contribution in the 1986-87 financial year; we shall have to consider carefully whether it can be maintained thereafter.’ (CRC AR, 1985).

The ICR was highly regarded and praised by the then CRC chairman as highlighted above. Then in 1986 the CRC decided, with agreement with MRC, to entirely take over the MRC share of ICR funds. This agreement negotiated at time when the joint funding (the CRC share) of the ICR was due to expire in March 1987:

‘Third, I referred last year to the increase in our share of the joint funding with the Medical Research Council (MRC) of the Institute of Cancer Research. The Institute, with the Royal Marsden Hospital, constitutes the largest comprehensive cancer centre in the UK. There would be considerable benefit to the national cancer research effort, as well as to the Campaign and the Institute, in a closer association between the two bodies. Furthermore, at present the Institute draws its funds from a variety of sources which has hindered the development of coherent scientific plans. During the year discussions have been held with the Institute and MRC to find a satisfactory basis for a closer relationship between the Campaign and the Institute. The working proposal is that the Campaign would take over the MRC’s share of the funding of the Institute over a 10 year period at the end of which time we would be responsible for over 60% of the institute’s funding, amounting in current terms to some £7m p.a.’ (CRC AR, 1986).

The increase in the CRC support for the three institutes, at that time accounted for 40% of its total expenditure on main objects. This helped the CRC to demand and achieve more control on the scientific activities in these key institutes:

‘Campaign support represents 85 percent of the total annual budget of the Beatson and the Paterson (£2.0m and £2.6m respectively) and 30 per cent of that of The Institute of Cancer Research (£3.5m). With the exception of The

Gray Laboratory, which has always been wholly Campaign-funded, the proportion of the Campaign's financial contribution to the institutes has been increasing and yet its involvement in the formulation of their scientific policies has not increased to the same extent. For some time it has been clear that the present situation was not satisfactory, particularly because the uniqueness, indeed raison d'etre, of the institutes - the strength and breadth of their scientific expertise and their ability to redeploy resources to tackle important areas of research as they arise - was not in the past readily accessible to the Campaign's national cancer research programme. New arrangements have now been agreed with the Directors of the institutes so that, through subcommittees of the Scientific Committee, the Campaign can be involved in the development of scientific policy and strategy; although without compromising the authority and responsibilities of the Directors. It should perhaps be added that the quality of the research at the institutes is not in question - peer review by means of regular subcommittee site visits has ensured this.' (CRC AR, 1986).

This gradual progression of the CRC's financial power enabled the CRC to strengthen their expansion policy and allowed it to have its say in the type of research it regarded as important and which merited support. It also appeared that this policy (i.e., strengthening and expansion of CRC influence on funding decisions) had been under discussion for many years and the work on this had been ongoing:

'For some time the Scientific Committee has expressed the wish that the Campaign should become more involved in the research endeavours of the Institute (referring to the ICR) which, with the Royal Marsden Hospital, represents the largest comprehensive cancer centre in the United Kingdom.' (CRC AR, 1986).

To achieve the above, the CRC set up a Scientific Policy Review Subcommittee of the Scientific Committee. According to CRC, the reason for setting up this new subcommittee was because of: *'the increasing need to identify research priorities, to maximise new opportunities and to coordinate the Campaign's national research effort'* (CRC AR, 1986). These goals noticeably reflect the funding body's desire to have more influence on driving certain research areas.

The Scientific Policy Review Subcommittee, according to CRC, *'has played an important part in identifying priorities and developing the Campaign's long-term scientific strategy.'* This subcommittee chaired by Professor Bagshawe (also the Scientific Committee chairman), and comprised the following members of the Scientific Committee - Professor Adams, Dr Connors, Professor Crowther, Professor Evans, Dr Garland, Dr Gurdon and Professor Harnden. They met at monthly intervals with the help of some members of the scientific committee and others selected from the campaign's grantees. These members reviewed about 40 percent of the Campaign's research portfolio in 1986, and planned to

review more in the following year. They recommended further research in the following areas:

- radiobiology (in association with the future of The Gray Laboratory)
- virology
- oncogenes
- growth factors
- primary and secondary prevention
- breast cancer
- familial predisposition and cancer genetics
- targeting in relation to tumour imaging as well as therapy

They also highlighted key themes according to the CRC report, which were:

- *'the serious shortage of post-doctoral research scientists and the urgent need to recruit and retain the very best to carry out cancer research.*
- *it is important to provide good research facilities so that all scientists can achieve their maximum potential - and the Campaign endeavours to ensure this.*
- *Individual financial rewards are also important and although the recently agreed national pay award has averted a serious crisis, something more is required to ensure that the opportunities for scientists in cancer research in this country can compete with those on offer in the USA or by industry.*
- *the need to encourage clinical cancer research and to promote effective links between clinical and laboratory scientists, especially in relation to the new developments in molecular biology'* (CRC AR, 1986).

The above mentioned issues also reflected the interest in molecular and genetic techniques, technological development, collaboration, and career structure. These issues discussed later within the key study themes.

Later in 1987, the CRC scientific committee made another decision described as the “*most important*” that year, which another step forward to expand and strengthen the CRC presence. It also reflected the scientific policy review conducted in the previous year. This decision was to agree to the building, at a cost of £1.65m, of a new cancer research centre at Cambridge University. The purposes of this development were apparent in the following CRC statement:

'It is intended that the development will stand on its own as a centre of excellence and attract young world class scientists. It will give the Campaign a clear identity in Cambridge and act as a focus for fundraising activities.' (CRC, AR, 1987).

There was consensus and eagerness about this new proposed centre:

'The proposals the Committee have enthusiastically agreed to a scheme put forward by Professor John Gurdon and Professor Ron Laskey - whose Campaign funded research groups will form the scientific nucleus of the new research centre.' (CRC AR, 1987).

The two scientists proposed this project were already working at Cambridge University, but it was not clear whether the CRC approached them or they introduced the proposals without any prior discussions with the CRC, which seemed unlikely. This is because both of their work was already funded by the CRC. The new centre also housed the new Centre of Developmental Biology funded by the Wellcome Trust (WT). The plan was that the new CRC building would contain six research groups which, according to CRC, *"although independent, will interact with each other and collaborate closely with both the new Wellcome Centre as well as other scientists in Cambridge."* (CRC AR, 1987).

This indicated that there was prior discussion and coordination with the WT.

Political influence

Funding certain research studies has also increased the funding bodies' political power, particularly the nongovernmental CRC. For example, the CRC was involved in influencing public health policies using its supported research findings. For example in 1985 the CRC influenced the decision to increase tax on tobacco:

'We have written to the Ministers responsible for the voluntary agreement between the tobacco industry and the Government and have drawn their attention to Campaign funded research which showed how much even quite young children are aware of tobacco advertising and sports sponsorship and affected by them. We also wrote to the Chancellor of the Exchequer about the need to increase tobacco tax to discourage smoking, and it was gratifying that Mr Lawson announced in his 1986 Budget that he was increasing the duty on cigarettes on health Grounds.' (CRC AR,1985).

In 1986 the British Medical Journal published a systematic review undertaken by the Campaign's researchers found that non-smokers living with smokers had an overall increase of lung cancer of 35 percent compared with non-smokers living with non-smokers. The CRC reaction to this was to influence future policies on smoking by ensuring that policy makers had access to their findings:

'Because this issue is especially relevant to the development of policies on smoking restrictions in public areas, it is important, in the Campaign's view,

that those likely to be involved in the debate should have the latest scientific evidence. Reprints of the article have therefore been sent to all Members of Parliament and Chief Executives of Local Authorities together with a letter drawing the key points to their attention.’ (CRC AR, 1986).

7.5.2.3 Case studies to illustrate the influence of all study themes on funding

During the period under review two research programmes were initiated because of public and political interest. They also demonstrate the influence of the leadership in funding certain research areas or fields, as well as the effect of the development of new methods, technological development, and collaboration on funding policies. Both programmes’ development was followed as this illustrated how biomedical research funding can be influenced by issues other than merely health or scientific matters. Both programmes were established due to a combination of key well-established scientists and scientific needs, and unexpectedly favourable political circumstances. The programmes were the Aids Directed Program (ADP) and the Human Genome Mapping Project (HGMP).

Aids Directed Program (ADP)

In 1983, the MRC had established a Working Party on AIDS (AWP) to review progress, coordinate research in the UK and provide expert advice. This was a standard MRC first response to a new scientific problem or opportunity. In previous years the Council had made similar responses towards research in other areas such as contraceptive hormones and kidney transplants.

In the 1984/85 AR, in reference to AIDS, the Council stated that: *‘it must be a matter of great concern if the resources needed to fund such work cannot be made available’* (MRC AR, 1984/85 p7). At that time the Council's grant-in-aid had declined by £2 million in real terms, and a similar trend had been apparent in the previous few years’ allocation of funds, as the MRC had suffered cuts in funding throughout the early 1980s.

By 1987 attitudes towards AIDS in the UK had shifted, and AIDS became a policy issue of the highest priority. This was as a result of the shift in government perception from considering AIDS as a threat to minority groups (e.g. gay men) to regarding it as a threat to the general public (Berridge, 1996). The MRC was clearly dependent on extra funding if a major research on AIDS was going to happen as a response to such policy, particularly due to government cuts in the Council's grant-in-aid, and the strong competition from work in other fields.

In the 1986/87 annual report, the MRC expressed concerns about the growing seriousness of the “AIDS epidemic”. The then Secretary of the MRC, Sir James Gowans (with the support of the Chairman, Earl Jellicoe) produced plans for an MRC AIDS Directed Programme (ADP) to fund research into finding an AIDS vaccine and develop viral chemotherapy. Gowans presented these plans to the government in December 1986. The document suggested that Britain might lead the world in the search for a vaccine and that results would be available within five years. The government granted Gowans (who became the first director of the programme) an initial £1m, and in February 1987 further proposals for a £14.5 million research programme were successful. By 1991, the MRC AIDS Directed Programme was costing £9-10m per year (7-10% of the MRC’s total budget).

Gowans’s support and successful initiation of the programme can be explained by his scientific background and leadership position. In addition of being the Secretary of the MRC at that time (1977-1987), he was the director of the MRC’s Cellular Immunology Research Unit, at the University of Oxford, from 1963-1977 (MRC AR, 1977/78).

Industrial links were an important part of the ADP, which brought scientists and industry to far greater levels of collaboration and strengthened existing relationships. Efforts to develop a vaccine prompted the MRC, via the Programme, to sign collaborative agreements with industrial companies, such as Celltech and British Biotechnology (MRC AR, 1989/90). General collaborative research agreements were also signed with various companies. Both types of agreement contained terms that industrial companies would contribute to the research project, and detailed procedures regarding intellectual property, commercial exploitation rights and publication of results.

In 1993 the then Secretary of the MRC, Dai Rees appointed and chaired a review committee into the Programme. The review was partly prompted by the DoH’s decision to gradually remove ring-fenced funding on AIDS to the MRC and the issue of whether AIDS should have separate budget within the MRC (Berridge, 1996).

Human Genome Mapping Project (HGMP)

The HGMP was an international effort to map and sequence the human genome. It started in the mid-1980s and was completed in February 2001 with the publication of a working draft of the human genome sequence (Glasner, 2002). The largest group in the HGMP was from the United States (Cook-Deegan, 1994). The second-largest group was from the UK, led by Dr John Sulston (later Sir), initially in the MRC LMB, and later at the Sanger Centre

(the largest genome sequencing centre outside the US), which was largely funded by the Wellcome Trust, but also by the MRC (MRC AR, 1993/94).

The UK was involved from the beginning in debates about a coordinated HGMP. For example, John Sulston represented the LMB at the Santa Cruz meeting (the first meeting held on human genome sequencing at the University of California) in 1985 and Sydney Brenner (Director of the LMB) had a seat on the National Academy of Science panel that constructed the framework for the HGMP (Wilkie, 1993).

In the UK, the HGMP was proposed by Professor Sydney Brenner in 1986. This suggestion, according to 1990/91 MRC AR, was inspired because of the strong tradition of human genetic research and technology enjoyed by the UK. The Council, accepted the suggestion, and negotiated its funding with the government, which led to an award in April 1989 of additional funds, particularly for this project, totalling £11m over three years period. This does not include the MRC funds towards already established research on specific disease genes, and other genetic research, which continued to receive funding as usual. By 1992, the budget was £5.9 million per year, and when combined with other grants from within the MRC, the total was £20 million (Wilkie, 1993).

7.5.2.4 The effect of technological development and new methods

Technology played a key role in scientific development, and particularly genetic and molecular techniques, drug developments and diagnostic techniques and methods. The need for better quality tools and equipment had become increasingly crucial for scientific advancements and discoveries. Funding such tools and equipment as well as the space they needed therefore became a necessity.

The funding bodies initially seemed rather apologetic in their annual reports for supporting this kind of (usually expensive) building and equipment, but in later years they become part of the scientific research necessities because research could not be carried out otherwise. Molecular and genetic techniques were exceptionally supported despite the cost required to build special laboratories and buy new equipment to employ these techniques and methods.

CRC reaction to new methods and technologies

The priority of the CRC was to fund scientists rather than buildings or equipment, unless the work of these scientists could not be achieved without such resources, in which case, it would occasionally support them:

'It has frequently been reiterated that Campaign policy is to fund people rather than buildings but that we will help provide them if the prosecution of our

planned and proven research programmes would otherwise be impaired. Accordingly, as I write this statement, building work on behalf of the Campaign is in progress at four different places.namely new laboratories for the Department of Cancer Studies in the University of Birmingham; a laboratory for the Campaign's Experimental Cancer Chemotherapy Research Group in the University of Aston in Birmingham; and the laboratory for the Department of Medical Oncology at Charing Cross Hospital, while the fourth is an additional laboratory for the Institute of Cancer Research at Sutton.' (CRC AR,1981).

After the retirement of the Scientific Committee chairman and six other members in 1983, a new chairman and members were appointed. The committee reviewed the Campaign research activities and concluded that the initiatives begun five years ago were fruitful and some achievements were highlighted including:

'The Campaign was now responsible for some of the best cellular and molecular biology in the country, and was in the forefront with regard to the development of new anti-cancer treatments and the supporting clinical trials network necessary for their careful and critical evaluation.' (CRC AR,1983)

One issue which merits highlighting here is the committee's interest in research investment, which might be related to activities leading to drug development, testing and eventually licencing:

'It was stressed that once the decision had been taken to Support a substantial and worthwhile activity, it was essential that adequate funding should be provided to ensure maximum return from investment; the present financial pressures on the Universities meant that adequate University Grants Committee funds would no longer necessarily be available for the basic facilities once routinely provided under the dual support system.' (CRC AR, 1983).

Such activities, as described above, required a lot of investment and thus efforts were directed towards coordinated research programmes and collaborative initiatives from different fields, but mainly the biomedical and clinical disciplines.

It is also noticeable in the above statement, due to the lack of support to research at Universities from the government, the CRC was more accepting of the need to provide facilities (e.g., buildings and equipment) to support certain research activities or programmes. This issue was also emphasised the following year and the CRC supported 284 such grants in 1985:

'Occasionally the research effort in universities or research institutes is hampered by inadequate facilities such as insufficient space, out-dated laboratories requiring modernisation or the need for specialised new installations. In such cases the Campaign may provide a major capital grant so that vital cancer research is not restricted.' (CRC AR, 1984).

Interest in clinical trials

The CRC interest in RCTs started in late 1970s, since then there has been continuous development and support for this area. The chairman of the CRC highlighted this in the 1981 annual report:

'As regular readers of the Campaign's Annual Report will know, the promotion of well-controlled clinical trials to evaluate new cancer treatments was one of three major initiatives launched by the Campaign five years ago and it has since resulted in the setting up of the CRC Clinical Trials Centre at King's College Hospital Medical School, as well as the CRC Phase 1 Clinical Trials Sub-committee.' (CRC AR, 1982).

In 1982, there were two more developments in this area. The responsibility of the Phase 1 Clinical Trials Subcommittee was broadened to include Phase 2 Clinical Trials. To expand the work of this new Phase 1/Phase 2 Clinical Trials Sub-committee, two grants, one to Strathclyde University and one to the University of Aston in Birmingham, were awarded.

Furthermore, a new CRC Clinical Trials Unit was being established at the University of Birmingham to help with the organisation and analysis of clinical trials in the West Midlands region. In the same year there was a launch of the CRC Trial of Breast Conservation designed to compare mastectomy with the more conservative lumpectomy in the surgical management of breast cancer.

7.5.2.5 Collaboration

Development of new methods, drugs and diagnostic tools and techniques mandated researchers from different disciplines and expertise to collaborate for further developments and scientific discoveries. They needed scientific, technical and resource input from other disciplines and researchers. Funding bodies encouraged collaboration first to reduce cost and allow the use of resources from different fields. Furthermore, collaboration was necessary to achieve the funding bodies' goal of contributing to the social and economic prosperity through scientific advancement and development of new drugs, diagnostic tools...etc. Collaboration appeared in all themes emerged in this study and with all funding bodies; however, this theme was more pertinent within the MRC (as being the largest health research funding body in the UK). Hence, the following section discusses this theme within the MRC context.

Collaboration within the MRC

The MRC had increasingly been focusing on collaborative research, particularly with industry, and encouraging studies of potential products that could be commercialised. Similarly, this gave the impression that the MRC was progressively gaining financial

rewards through research collaboration and commercialisation. This is particularly evident in the annual reports by dedicating several sections to working with other organisations such as industry and the NHS.

On the other hand, the increase of the income from other sources came mostly after the 1990s, which reflected the government and MRC policies that supported and encouraged collaborative work; particularly with industry, and commercialisation of research (Figure 7-2).

One of the areas that prompted the MRC to encourage collaborative research, particularly with industry, was biotechnology and the potential economic rewards that biotechnology can bring:

'Biotechnology, the application of biological organisms, systems or processes to manufacturing and service industries, is likely to play an increasing role in the world economy in the future, for example, food and animal feed production, development of alternative energy sources, and medical and veterinary care. Accordingly, early in 1979, the Advisory Council for Applied Research and Development (ACARD) decided, in conjunction with the Royal Society and the Advisory Board for the Research Councils (ABRC), to set up a Joint Working Party... to study the industrial applications of biological knowledge.' (MRC AR, 1979/80).

The Working Party later in 1980 recommended that the Research Councils' support for biotechnology should amount to at least £3m a year and that they should coordinate their activities in this field. They also recommended that the University Grants Committee and the Research Councils, with the backing of the universities, should support the expansion of a limited number of centres of excellence in biotechnology from the best existing in universities.

The MRC identified basic research at molecular and genetic level as potential area for commercial exploitation:

'In biomedical science, basic research on the cell at the molecular level has now reached a stage at which the knowledge acquired is potentially of considerable relevance to clinical medicine, in particular through the exploitation of sequencing techniques, genetic manipulation and monoclonal antibody production. The MRC has a vital role to play in supporting fundamental research in these areas which underpin the application of biotechnology both to medicine and to industry.' (MRC AR, 1979/80).

An important criterion to build a research programme in universities was also the potential for collaboration:

'The Council also seeks to place its own units within universities where there is mutual benefit from collaboration between units and university departments.'
(MRC AR, 1981/82).

This potential collaboration encouraged MRC to fund certain projects particularly if this would potentially lead to commercialisation:

'A new Histopathology Section (Head: Dr G Slavin), comprising the former Histopathology Group and Electron Microscopy Section, has been set up at the Clinical Research Centre. Among the Section's proposals for future work is a collaborative venture in neuropathology with the Royal Postgraduate Medical School, London. It is hoped that investigations of clinical interest will arise out of the wealth of diagnostic material available and so relate closely the research and service sides of the Section's work.' (MRC AR, 1981/82).

However, the MRC realised that commercial exploitation in this area was costly, and required a lot of resources that were already lacking:

'The field is advancing very rapidly but it is also very expensive in terms of manpower, consumables and other general support facilities and there are insufficient skilled staffs to meet industry's future needs.' (MRC AR, 1979/80).

Despite this lack of resources the MRC planned to increase funds to this area, particularly when promising research has already been completed:

'The Council's aim is therefore to expand where appropriate the level of support to teams already funded by the MRC and also to attract more young scientists into the field through studentships and by providing additional training posts in existing teams. The Council would also wish to be able to carry projects forward from a point where the basic research has been done but the commercial development has not yet begun—the 'intermediate development gap'—but, while the Council will provide what resources it can, additional funding will be needed for that purpose. While funds remain limited, the Council must continue to preserve and expand its strength in the basic research that will lead to the biotechnological development of the future.'
(MRC AR, 1979/80).

The following year, 1980, the MRC entered a five year collaborative agreement with Celltech Limited in the areas of genetic manipulation and monoclonal antibodies. The motive behind this collaboration was to allow for biotechnical development through sharing the expertise of MRC scientists and industry, as well as sharing the cost and resources required:

'This agreement is making possible close working relationships between scientists in MRC establishments and Celltech scientists and provides for the transfer to industry of MRC discoveries and know-how through Celltech. A substantial part of any royalties payable by Celltech to the MRC will ... be credited to a special MRC fund, The Celltech Fund, to finance additional biomedical research.' (MRC AR, 1980/81).

Under the Council's agreement with Celltech Ltd the Council could nominate one person for appointment to the Board of Directors of the Company, which advises the Company on scientific matters, and the then Secretary to the Council was serving in this capacity. This is again shows the importance of this kind of collaboration. The MRC later identified areas of potential commercial exploitation and increased its support to them, for example:

'Developments in molecular biology have made it possible to design and construct novel proteins (e.g. enzymes and hormones) - by so-called 'protein engineering' -for specified applications in the chemical, food, pharmaceutical, waste-processing and other industries. Collaborative research between scientists at the MRC Laboratory of Molecular Biology, Cambridge (LMB) and Imperial College, London, has demonstrated the potential value of this approach for enhancing enzyme activity and has provided an important model system in which to develop the methodology. The techniques can be applied, for example, to the construction of novel vaccines and peptide hormones and to the manipulation of enzymes important to industry and medicine. This is an area of research which is of interest to both SERC and the MRC, and a coordinated approach to its further development will be made. The Council plans to build on existing expertise in protein engineering at LMB, at an estimated cost of £0.2m over two years.' (MRC AR, 1981/82).

The decision to fund this area was also influenced by Inter-Research Council Coordinating Committee (set up in 1980 to advise the Heads of the Research Councils on the development of the biotechnology research programmes within the research council system, and any new work that should be initiated) report. The report identified an opportunity for inter- research council coordination in producing synthetic vaccines, and suggested areas of work that needed to be stimulated to remedy inadequate coverage - notably microbial physiology and plant molecular biology and biochemistry.

The decision, in 1981, to appoint Dr Dai Rees as the director of the NIMR might not be a coincidence, considering his academic and industrial background:

'The Council attach great value to Dr Rees's academic and industrial experience, seeing in his appointment (NIMR director) opportunities for strengthening the Institute's links both with universities and with British industry.' (MRC AR, 1981/82)

The MRC has continued over the years to collaborate with several other industries and universities for the same purposes, and generated funds through this:

'The Council aims to ensure that discoveries made with public money contribute to the nation's economic performance. To this end, policies are designed to promote closer links between MRC scientists and industrial concerns so as to encourage and facilitate the transfer of the results of Council's research to industry. The Council have about 100 inventions licensed or under exploitation by the British Technology Group and some 40 know-how agreements with commercial organisations.....Receipts from

industrial sources amounted to £0.7m in 1983/84. (MRC AR 1983/84)

Eventually the MRC Collaborative Centre became incorporated as a company in 1985.

7.5.2.6 Funding issues related to epidemiological studies

It would have been ideal to provide statistical information about the number of OE studies funded by each funding body compared with other epidemiological and health research studies. Unfortunately, details about this information were not available in the annual reports of the three funding bodies included in this study. Additionally, it was not possible to identify other sources that could possibly include this information. However, some useful data is relevant and the results are presented in the next sections.

CRC funding of epidemiological studies

The CRC listed all projects funded each year up to 1990 in the annual reports. The amount of funds allocated to each project is not mentioned, however, the total amount of funds allocated to each University and Institute is specified. This fund specified in the reports covered all types of projects undertaken in each university and institute. Thus, it was not possible to quantify the amount of funds for certain types of projects. However, it was possible to identify all epidemiological studies supported by CRC during 1980 to 1990. From 1980 to 1990 CRC funded 60 epidemiological studies. From those only 15% ($n = 15$) were OE studies and the majority 73.3% were PHE ($n = 44$) (see Table 7-1).

Four out of nine OE projects ended in 1981, one project ended in each of the following years: 1983, 1985, and 1987 Only 2 projects continued beyond 1990 (see Appendix D-4).

All the researchers who have conducted the OE studies were also conducting PHE projects and were recognised as public health epidemiologists. Furthermore, the departments in which the researchers were based were mainly called epidemiology units/groups. None of these units or departments was referred to as being an OE unit, group or department (see Appendix D-4).

Table 7-1 : Number and types of epidemiological studies funded by CRC 1980-1990

Type of study	Number of funded studies	Percentage
OE	9	15
PHE	44	73.3
clinical epidemiology	6	10
Both (OE &PHE)	1	1.7
TOTAL	60	100

The CRC regarded epidemiology as an important area of research; however, as shown in table 7-1, the CRC generally supported small number of epidemiological studies, particularly in the occupational health field:

'Major initiatives taken by the Campaign in the important area of research into prevention include the setting up of the Department of Epidemiology at the Institute of Cancer Research in London and the Cancer Epidemiology Research Group in Oxford.' (CRC AR, 1981)

The departments mentioned above produced the most epidemiological studies funded by the CRC. The areas of concern at that time, as mentioned in the report, were related to the effect of diet on cancer and childhood cancers, which are public health issues rather than occupational health and attracted government and public interest at that time:

'Among a wide range of investigations into why people develop cancer, a topic of current concern is the role of diet in cancers of the digestive system. One study related to food involves immigrants from India and Pakistan, another looks at groups of nuns and the relevance of their meatless or nearly meatless diet. Childhood cancers obviously have a significance out of proportion to their relative rarity, so researchers are examining all the causal factors that may be implicated.' (CRC AR, 1981)

The lack of CRC funds to epidemiological studies, particularly in the OE field, could be mainly because the CRC support for research on cancer prevention has been primarily on education rather than epidemiology. In 1977, the Campaign set up a Cancer Education Panel and in 1984 an Education Committee was established, which had full Standing Committee status, to encourage and fund research in this area. The main purpose of this research was to educate the public, health professional and patients.

Additionally, the importance of epidemiological research was primarily linked to clinical and laboratory based research:

'Epidemiological research provides a starting point for clinical and laboratory investigation of causes. Laboratory-based research into carcinogenesis in the Divisions of Chemical Carcinogenesis at the Paterson Laboratories in Manchester and the Institute of Cancer Research involves detailed studies of chemical agents that may act to initiate cancer or speed its development. The relationship of cause and effect in cancer is not simple and individuals respond differently to cancer hazards. Knowledge of how the body deals with exposure to an agent, how it repairs damage or resists cancerous changes, could lead to means of protection as well as ways of avoiding the effects of agents.' (CRC AR,1981)

The above statement was stated in a context of mentioning the importance of epidemiological studies, yet it turned the focus on the importance of basic and clinical

research. This statement reflected the CRC perception; that a lot was achieved in epidemiology, and that more was needed in basic and clinical sciences.

HSC funding of occupational epidemiological studies

Asbestos, construction, dusts, genetic manipulation, ionising radiation, lead, noise and vinyl chloride hazards, were some of the first key areas HSC had focused on. Its responsibilities towards health and safety regulations and enforcement have increased over the years. Some other key areas including responsibilities for: the control of major hazards under the Seveso Directive (1984), safety regulation of gas transmission (1985), control of pesticides under the Food and Environmental Protection Act (1986), nuclear safety research on established systems (1990) railway passenger safety (1990), and offshore safety (1991).

In the HSC annual report 1991/92 the trends of greatest importance of HSC work over the past decade had been highlighted this included:

- *“our steady acquisition of new responsibilities;*
- *a gradual shift of resources and interest towards occupational health and hygiene and a better appreciation of the consequences of occupational ill health in terms of time off work and premature retirement. The COSHH Regulations have provided the basic underpinning for more effective protection of the health of employees;*
- *a shift in the balance of our activities towards major hazards and the protection of the public from industrial harms, while fully maintaining our concern with the protection of employees;*
- *a much increased international commitment, expressed partly in a shift of focus to the European Community which now markedly determines our priorities and to an extent our policies;*
- *a marked increase in public concern for and in the subject matter of our work, and particularly its environmental aspects.” (HSC AR, 1991/92).*

The added responsibility and the trends mentioned above reflect the increased focus on public and environmental hazards arising from work. This is due to the increased public awareness of work related hazards on the environment and subsequently on public health.

This issue was previously implied in the HSC 1990 annual report:

‘The Commission and HSE were told by the Parliamentary Select Committee on Employment nearly a decade ago that we had to acquire a higher public profile to do our job properly..... The Commission too has changed in form. When a new Commission was formed in March 1990, the Secretary of State signalled the increasing importance of public health and safety elements in our work by appointing a ninth Commissioner to represent the public interest.’ (HSC AR, 1989/90)

The work of the HSC had been reactive to health and safety issues arising due to new hazards, accidents and disasters. Additionally, their work and focus was influenced by

social, economic and political situations; particularly the impact of European Community health and safety laws that the UK had to incorporate into its domestic laws:

'New developments that nowadays shape so much of our work had begun to outline themselves - increased activity in the industrial safety area by the European Community; the rise in public concern over industrial harms; and changes in industrial structure reducing the importance of the heavier industries. But we knew nothing then of the transnational implication of Bhopal or Chernobyl, or the global consequences of pollution, or of the Single European Act and the impact of qualified majority voting in the European Community.' (HSC AR, 1989/90)

The political and economic circumstances of the period had shaped much more of the HSC's work. Being a governmental body it was obligated to follow its economic and political interests:

'In early 1993 the Government's deregulation initiative was given renewed impetus, with a commitment by Ministers that all existing legislation should be reviewed and unnecessary burdens on industry removed. In January 1993 HSC accepted Ministers' invitation to undertake such a review of existing health and safety legislation. HSC has a continuing role to ensure that necessary standards of health and safety are maintained or improved. The aim of the review is to examine whether there are obligations arising for business which can be eased or simplified without endangering such standards' (HSC AR, 1992/93)

The regulations, laws, and enforcements of the HSE had improved health and safety regulation at work and continued to deal with any new hazards as they became known (as highlighted above as being one of the HSC achievements). This gave the impression that these are under control, particularly for already known hazards, and this may have negatively influenced the funding of OE studies

7.6 Section three: discussion

This study investigated the influence of funding policies and allocations of fund on the development of health research fields. Through this investigation, a better understanding of what influence the development of OE field was sought. The key findings of the study are discussed including: key leaders and researchers influence on funding policies and scientific fields' development; the influence of collaboration and technological, scientific and methodological development; and the influence of internal and external policies. This followed by the conclusions of the chapter.

7.6.1 Key leaders and researchers influence on funding policies and scientific fields' development

The documentary study shows that leaders and researchers who held leadership positions in funding bodies and higher education institutions linked to these funding bodies had

influenced the funding policies and distribution of funds to certain areas and fields, and hence these fields' development. Their influence is rooted in their political, scientific, and professional backgrounds. Researchers in the basic science fields had dominated and received the most funding during the study period. One reason for this was that important discoveries that have commercial applications were made by them (DNA sequencing and monoclonal antibodies for example). Those who contributed to such discoveries were usually honoured and promoted to leadership and managerial positions. Their own research area or/and other areas they had an interest in were also supported, and sometime without the requirement of grant applications or review. Many of these leaders were also involved in the funding bodies' boards that were responsible for prioritising research areas, and setting funding policies and organisational strategies.

As Braun (1998, p. 812) argues:

'In fact, one can observe that the goals of funding administrators (enlarging funding programs to extend their domain of influence) and scientists (obtaining a maximum amount of funding resources for their research field) do converge and that no goal can be reached without the active cooperation of both sides. This is why one finds close networks of funding administrators and scientists in a multitude of funding areas.'

The process of interaction between scientists, funding administrators and politicians within the funding bodies decides the success or failure to influence scientific development by funding policies (Braun, 1998). In this study, the government had the main control on some of the funding bodies by its control on appointing the key leaders and administrators within these bodies. Such leaders were largely those with industrial background to facilitate the commercialisation of research ideas, and increase the cost effectiveness of the funding bodies. Thus, they had largely directed funding to certain research areas and fields influencing their developments. In this regard, the role of key researchers and political leaders in the development of scientific fields was clearly demonstrated by Doll when he was asked about how epidemiology was practiced when he started his career:

'Just after the war there really wasn't a subject of epidemiology in Britain. However, quite a few young people were concerned about the social causes of disease. We were fortunate in that the then Secretary of the Medical Research Council was sympathetic to the idea that social and environmental factors might be important causes of disease, and he set up several units investigating such factors which, in effect, turned into Departments of Epidemiology. One of these was the Social Research Unit under Jerry Morris at a London hospital. Professor Ryle at Oxford was, however, really the first to make the term "social medicine" acceptable in university circles. Young people, such as Archie Cochrane, Jerry Morris, Donald Reid, John Pemberton, myself and several others, gathered around those few senior people who were interested in developing the subject. The whole world was open to us because there had been so little exploration of the field at that time.' (Darby, 2003, p. 375)

The importance of the key leaders in epidemiological fields was further confirmed by Doll when he advised young epidemiologist to work with the best scientists in top organisations:

'I have no doubt that the most important thing for a young person to do is to get attached to a good epidemiological unit. Preferably, the best one there is in the country. He or she is going to learn by seeing how epidemiology is practiced by colleagues, and the best way to do this is by working with the best epidemiologists. So what I would say to a young epidemiologist is go for the top and work with the best people.' (Darby, 2003, p. 378)

Epidemiologists, particularly in the OE field, faced more challenges in becoming senior researchers and leaders in their fields. If not medically qualified they needed to compete with those who were medically qualified, and this was challenging and required more time. If medically qualified, the lower salaries in academia (at least during the study period, but not now) compared to clinical fields, discouraged them to be involved in epidemiology (Holland, 2002). This may have prevented them from becoming prominent leaders and less involved in governmental and funding bodies activities. Richard Doll highlighted this point in an interview in 2003 when asked about the current state of epidemiology in the UK:

'In Britain, it's not very good. The criteria that are laid down now for advancement from junior to assistant to professor are very difficult for an epidemiologist to progress through in this country. This is because of the way that salaries are determined and the need, if you are medically qualified, to get classified as a consultant. There are also so many bureaucratic obstacles now to carrying out epidemiological studies per se. I was very fortunate to be able to work without having to worry about them.' (Darby, 2003, p378)

Doll also criticised higher education institutions and leaders in these institutions for neglecting epidemiology and their preference of supporting studies using new methods and techniques, which he thought one of the reasons why epidemiology was not in a good status in the UK:

'Universities, too, have become so enthralled with molecular genetics that senior people tend to relegate epidemiology to a very minor corner of medical schools. I think this is an error because molecular genetics is still going to require epidemiological observations to determine the important causes of human disease.' (Darby, 2003, p378).

7.6.2 The influence of collaboration and technological, scientific and methodological development

The study findings demonstrate that research collaboration has been encouraged and influenced by the; key researchers, funding bodies, and government. Collaboration has also been encouraged to occur at different levels; between individuals, groups, industry, and institutions or across them.

For scientific development and discoveries to take place, it was necessary to involve different expertise and research fields. Professionals had to seek the knowledge of other professionals either from similar disciplines (e.g. medicine and biology) or other fields (e.g. information technology, engineering and physics) to help advance methods and scientific discoveries. Similar reasons were also mentioned for research collaboration including: accessing expertise, accessing equipment or resources, encouraging cross fertilisation across disciplines, improving access to funds, obtaining prestige or visibility, learning tacit knowledge about a technique, sharing knowledge for tackling large and complex problems, enhancing productivity, educating and training students, and increasing the specialisation of science (Bozeman & Corley, 2004; Defazio et al., 2009).

As new methods developed and technology advanced, more resources and more sophisticated equipment and laboratories were needed. Researchers could not carry out experiments or certain methods and techniques without such resources and other expertise from different fields. This increased the cost of conducting research and researchers had to compete for funding; otherwise, important research could not be carried out. Consequently, institutions and funding bodies encouraged researchers to seek funding from other sources, share resources and consequently encouraged collaborative research. Political factors have also become more pronounced within certain funding agencies, in particular the European Commission, requiring researchers to seek collaborative partners before they apply for financial support (Katz & Martin, 1997).

Some government policies related to collaboration had been deployed, including financial incentive for research collaborations such as; the White Papers ‘The Health of the Nation’ and ‘Realising our Potential’. Many different forms of research collaboration were established in response to these public policies. Funding bodies had furthermore realised the importance of scientific advancement for socioeconomic benefits (Furman & Gaule, 2013) through developing healthcare products and improving healthcare services. The funding bodies had welcomed the increase in collaboration between different groups and organisations and emphasised the great benefit of this collaboration to society. In particular, industry collaboration as it facilitated the transfer of basic knowledge and accelerated the exploitation of new inventions. For the funding bodies, the financial benefits from patents (through licenses and royalties) and spin-off companies provided additional sources of funding, which were allocated to new research areas. For example, the MRC and CRC, during the study selected period, had established their own companies to commercialise

research ideas (e.g. drug development and healthcare products) generated by their scientific community members.

Collaboration and the utilisation of new technologies and methods are also important in epidemiological fields. Doll emphasised that the most important factors for an epidemiologist, in order to have a productive career, are collaboration and the utilisation of new technologies:

'The possibility of collaboration is certainly vital. Collaboration with people who have a good understanding of the major medical problems in the world is, I think, the most important thing for an epidemiologist. Of course, it is becoming increasingly difficult to solve problems of etiology by epidemiologic methods as the easy things have been done. I am certain there still remain many problems that can be solved, but it is necessary to collaborate with specialists in the relevant fields to solve them. Nowadays, of course, access to good computing facilities and knowledge of how to use them is also very important, whereas computers were nonexistent when I entered the subject.' (Darby, 200, p378).

Doll was referring to collaborations between scientist and academics, but not industry. Some authors have expressed concerns about the possible effects of the increased emphasis on knowledge and technology transfer (Geuna & Nesta, 2006). Florida and Cohen (1999) argue that industry collaboration and commercialisation might come at the expense of research, or at least of basic research. The increasing connections with the industry might be affecting the choice of research projects, shifting academic research from a basic towards an applied approach. Nelkin (1984) also warns that the pressure to transfer technology and knowledge might jeopardise the intellectual commons and the practices of open science.

Furthermore, commercial development might delay or conquer scientific publication and dissemination of results (Banal-estanol et al., 2009). Pearce (2008) also cautioned against OE researchers to collaborate with industry for similar reasons. In this study, OE researchers found it difficult to collaborate with industry because the fear of litigations, the decrease in heavy industry, and the lack of pressure from government (e.g., HSE). On the other hand, OE collaboration with industry is primarily for investigatory purposes rather than economic profits; thus, industry would be less likely to collaborate with OE researchers. For the same reason, funding bodies may prefer to support other fields with potential commercialisation ideas, which was evident in this study. Despite that the some authors warns from industry collaboration, Gulbrandsen and Smeby (2005) found that there is a significant relationship between industry funding and research performance. They further reported that professors with industrial funding; pronounce their research as applied

to a greater extent, collaborate more with other researchers, and report more scientific publications and entrepreneurial results (Gulbrandsen & Smeby, 2005).

7.6.3 The influence of internal and external policies

UK suffered economic recession throughout the 1980s, and as a result the government decreased funding for research in research councils and higher education. As funding had decreased the funding environment had become more competitive. Since then, government and funding bodies' policies had been pushing for enlargement of external funding, particularly from industry, to relief some of the government budget. Geuna and Nesta (2006) note that since the early 1980s European governments have been intervening more directly in terms of directing national research systems. The expectation is that researchers not only produce new knowledge, but also this knowledge is related to specific social and economic targets (Kyvik & Lepori, 2010).

One of the main effects of these cutbacks was the increased adoption of researchers to government priorities without much obvious direction from the state (Martin & Richards, 2006). Academics and researchers began declaring the relevance of their work to state and corporate needs, rather than becoming critical to the state control (Martin & Richards, 2006).

For example, the AIDS and HGMP programmes were initiated due to political reasons; the public pressure for finding cure for AIDS, and the UK government interest in being in the forefront in developing the human genome (probably also for economic reasons due to potential commercialisation). Both programmes were Big Science (Price, 1963) projects, and for both the government was a significant sponsor. The government response to sponsor Big Science projects reflected broader issues in relation to scientific research funding. These issues were reflected in the MRC's approach to funding research on AIDS and Human Genome Project. The MRC traditional responsive mode of research funding was changed in 1986 by the MRC ADP, which reflected increasing adoption of Rothschild customer/contractor principles of the 1970s (MRC AR, 1977/78). The adoptions of these principles led to a shift from research for the sake of knowledge to research to meet problems and priorities that are high in the government policy agenda (Rothschild, 1971). Its influence was also reflected in the adoption of this principle in the HGMP.

Furthermore, the Programmes had a considerable training element, for example in ADP there were twenty PhD awards in virology and immunology and post-doctoral funding for

study abroad. Laboratories for growing the virus were established at Cambridge, Glasgow, the Chester Beatty in London, and the National Institute for Biological Standards and Control (NIBSC). The HGMP awards included not only research grants, but also training awards towards studentships, junior and senior fellowships, conferences, workshops and travelling awards. There was an interest not only to support research in this area, but also to train and prepare scientists to continue and lead future research in this area. Additionally, the majority of the funds in both programmes were directed towards basic science. The ADP, for example; was criticised by its focus on basic sciences and the lack of activity in clinical sciences, and this focus in developing a vaccine had more political influence than a clinical focus on treatment of those already infected (Berridge, 1996).

On the other hand, the government demanded effective management of the limited funds and cuts to research and other areas. Both the MRC and the HSC were continuously pressurised for better financial management and cost effectiveness of resources. Both bodies devoted a section in their annual reports to demonstrate this. Their financial management was regularly scrutinised by the government and several dedicated government reviews were conducted for this reason. These cuts to research funding also influenced other independent and charity funding bodies such as CRC. The demand on funds increased for these bodies and consequently they followed similar approaches to that of the government in terms of efficient financial management, collaboration, research commercialisation and prioritising research areas to suit their own interest. They also gained more political power due to their increased financial resources and the demand for their funds. For example, the CRC was able to gain complete control of the ICR, which was jointly funded by the MRC.

For economic reasons, the HSC was also pressurised by the government not to impose unnecessary financial pressure on industry to establish health and safety measures at the workplace. Additionally, many of the health and safety regulations were established either as a reactive measure to major events (e.g., Chernobyl disaster, Bradford City stadium fire) or as a result of relevant European legislations. These issues also may have impacted on research in general and on OE research in particular. For example, HSE nuclear research funding had increased after Chernobyl disaster. However, as evident in the HSC ARs, the decline in the heavy industry and the improvement in health and safety at workplace (due to the implementation of the Health and Safety Act 1974), could have negatively affected the funds for OE studies. This also might have influenced the perceptions of the government

and other funding bodies that health and safety of worker and employees are taken care of by HSC and thus research in this area may have become lesser of a priority.

7.6.4 Conclusions

This study indicates that the development of health research disciplines is influenced by funding policies and allocations of funds. Funding bodies played a vital role in this regard. There are several interwoven factors found to explain the influence of funding on research disciplines. The main factor identified is the role of key leaders and researchers within these bodies in shaping the funding policies and mechanisms. Their political, professional, and scientific backgrounds influenced their decisions. This led to skewing the funds towards areas of their interest and served their political and scientific agendas. Other factors identified are the influence of collaboration and technological, scientific and methodological development. Funding policies encouraged collaborations mainly to boost scientific advancement for socioeconomic benefits. Such advancement required collaboration with industry or other organisations, and exploitation of new technologies and methods. All these activities were supported by the funding bodies in terms of policies and funds. Finally, there were key policies primarily developed by the government that shaped the funding policies and mechanisms, which also encouraged collaborations, the development and use of new technologies and methods, and commercialisation of research ideas.

OE field has been influenced by the above factors because; the field is not represented within these funding bodies, the level of collaboration is low, and the use of new technology and methods is lacking. This field could benefit in the future if it considered these factors.

8 DISCUSSION AND CONCLUSION

This chapter summarises the main findings of this study, draws out their implications and provides potential suggestions for future work. The chapter is divided into seven sections. First, the work carried out and the main conclusions are summarised. Second, key findings from all phases of the study is synthesised and discussed. Third, the implications of the main results are presented including recommendations for researchers and policy. Fourth, avenues for further work are described. Fifth, a discussion of the strengths and limitations of the study is presented. The sixth section discusses the generalisability and transferability of the findings and the final section provides an overall discussion and conclusions.

8.1 Summary of key findings

This thesis comprised four phases and utilised sequential mixed-methods to investigate the challenges to and facilitators of OE research in the UK and to understand the impact of these on the field's development. In addition, the major issues identified in this study were further explored in comparison to other health research fields, which provided insights on key factors that influence the fall and rise of these fields. Table 8-1 presents an overall summary of the key findings from all phases of this research programme. The substantial findings in the context of the main overarching research aims are discussed.

Table 8-1: Key findings from all phases

Chapter Four Interviews & Survey	Chapter Five Bibliometric analysis	Chapter Six Documentary review	Comments
<p>The key challenge is the lack of human and financial resources</p> <ul style="list-style-type: none"> • Small community • Less funding and training opportunities • Key researchers are getting older, younger ones are difficult to recruit • Challenges and the impact of these are increasing over time 	<p>PHE has evolved over time while OE has maintained its size, and continued to produce similar number of studies and researchers:</p> <ul style="list-style-type: none"> • Number of publications and researchers has increased over time in PHE • The number of key researchers in OE field is getting fewer • Small number of new researchers enters the OE field each year compared to the PHE 	<p>Funding decisions in health research fields are influenced by:</p> <ul style="list-style-type: none"> • The influence of key researchers/leaders in positions of power or leadership • The influence of internal and external policies • Collaboration • Evolvement of new methods and techniques and technological development • Funding issues related to epidemiological studies 	<ul style="list-style-type: none"> • Findings from Chapter 4 & 5 confirmed the lack of resources in OE field. • The growth in PHE and the maintenance of the same size of OE mean that OE is getting smaller relative to PHE. This confirms that the impact of the challenges have increasingly affecting OE.
<p>Facilitators</p> <ul style="list-style-type: none"> • Effective communication with relevant stakeholders • The relevant stakeholders' cooperation, support and interest in the study • Government, media, and public interest in the topic • The availability and completeness of workers or employees records • Availability of resources • Rigorous study design 	<ul style="list-style-type: none"> • Collaboration and the use of new methods and techniques may have contributed to the growth of PHE compared to OE. 	<ul style="list-style-type: none"> • Collaboration • The adoption of new methods • Having representatives of the field within the funding bodies' review boards, committees and management teams • Understanding, participation and involvement in relevant policy issues and decision making-processes 	<ul style="list-style-type: none"> • Key leaders and researcher in OE field are less represented in the funding bodies' management, policy-settings and decision - making process. Thus, this field has become lesser of a priority to these bodies • Collaboration and the use of new methods have been encouraged by funding bodies, which are less evident in OE field. Thus, OE received less support from these bodies.
<p>Practical challenges:</p> <ul style="list-style-type: none"> • Ethics, governance and management clearances • Records issues • Low response rate 			<ul style="list-style-type: none"> • These issues can also be experienced in any other health research fields as discussed in chapter 1.

8.1.1 Practical issues

The literature review showed that the challenges and facilitators of OE research are not sufficiently discussed and there were no empirical studies designed to explore these issues. A number of OE researchers reported difficulties related to the validity and generalisability of studies owing to small sample size or insufficient data. Therefore, the first two phases of this thesis was designed to examine the challenges to and facilitators of OE research in the UK, the impact of these, and strategies employed to overcome the challenges.

The first phase comprised a qualitative interview study of key UK-based OE researchers, which aimed to explore their perceptions and experiences of challenges and facilitators, the impact of these on their studies, and how they overcame these challenges, where possible. The key researchers highlighted the main challenges to conducting OE research in the UK including: lack of funding, difficulties in accessing data and participants, lack of expertise, records issues, recruitment difficulties, and publication issues. Additionally, they identified the facilitators, strategies they have employed to overcome some of the challenges, and provided recommendations to improve carrying out this type of research in the UK (see Table 8-1).

However, because of the small number of researchers interviewed in the first phase, it was important to investigate whether the reported issues by this sample are applicable to and not different from those experienced by the general OE community. Additionally, it was necessary to identify any other issues not reported in the literature or by the interviewees. Therefore, a survey of the broader OE community was conducted in the second phase of the thesis. The survey questionnaire was specifically designed using findings from the systematic review and the interview phase. In addition, an opportunity was given to the participants to add any new information by asking open-end questions in the study questionnaire. The participants of the survey phase confirmed the findings found in the previous phases with some variations in the emphasis on the key challenges. Furthermore, there were no new findings or any reported issues that were different from the findings of the previous phase.

These practical facilitators and challenges could be general issues experienced in other health research fields and not particularly specific to the OE field. However, these challenges can be more problematic to OE studies than other fields due to its specific characteristics (discussed in Section 1.3.6). In particular, this occurs when potential participants can only be found in a specific industry or area of employment, where the

industry management or employer has the primary role in deciding whether researchers can access them or not. Industry management or employer may however refuse access to participants and data for various reasons such as fear of litigation or work disruption. Additionally, confidentiality law requirements may jeopardise the study conduct and conclusions, particularly due to the requirement for informed consent, opt-in approach, and including the GP or other health professionals as a gatekeeper to approach participants.

OE studies pose very few risks to the investigated populations when compared to RCTs or some other epidemiological studies. This is because the vast majority of populations studied in OE research are largely fitter (Shah, 2009) (See the healthy workers effect in Section 1.3.6) and less vulnerable (healthy adult) compared to those populations of the RCTs (mostly sick) and the PHE (includes children and elderly). Generally, RCTs are designed to test new treatment on patient populations, whilst epidemiological studies are observational in nature with no intervention. Therefore, it could be rightly argued that the ethics and governance frameworks that have been implemented almost similarly to all types of health research are not fully justifiable to be used in the field of OE (Peto, Fletcher, & Gilham, 2004). The use of opt-in methods for consenting participants, the use of other health professionals (e.g., GPs) as gatekeepers and forbidding OE researchers from contacting these participants directly are particularly unjustified and require future review by the regulatory bodies.

8.1.2 Lack of human and financial resources

The key concerns of OE researchers in the first two phases were the lack of human and financial resources, which threaten its sustainability and development. The interview and survey phases also provided evidence that the OE community is small compared to other epidemiological and other health disciplines.

However, it was not sufficiently clear from these analyses as to why these challenges occurred, and whether these are experienced in other health research fields. This indicated that further research was required to explore whether these challenges are present, if present, how they were established, and to identify the factors that contributed to their development in OE compared to other fields. Therefore, these issues merited further exploration in the bibliometric analysis and the documentary study phases. It was also necessary at this point to address these questions more objectively.

The bibliometric phase (phase 3) of the study investigated these issues through examining the contribution of OE to the cancer field compared to that of the PHE over time. Through

this evaluation, it was possible to identify how each field evolved over time and what contributed to it in terms of publications output, citation, and authorship characteristics. Another objective of this evaluation was to identify particular time periods and particular issues in which divergence had occurred between the OE and PHE fields. Cancer epidemiology is regarded as a pioneer in epidemiological studies since the 1960s (Checkoway et al., 2004; Coggon, 1999), and thus a high proportion of researchers and resources are likely to have been invested in this field. Therefore, it was anticipated that sufficient and rich data are to be found for the bibliometric analysis. Thus, this field was chosen for the purpose of this investigation.

The bibliometric study confirmed the key findings from the previous phases. More importantly, it showed that the number of PHE publications and researchers has increased over the years; while the OE has maintained its size, and continued to produce approximately the same number of studies and attract the same number of researchers over the years. This phase also indicated that the divergence and the differences between the two fields started to occur in the mid-1980s.

Several factors may account for this difference in trends and developments including collaboration, and adoption of 'new or cutting-edge' methods and techniques (e.g., molecular and genetic techniques). However, other factors may have also contributed to this difference including; funding availability, scientific and technological advancement during recent decades and their implications for the workforce and workplace environment, and the influence of leading researchers.

The findings presented in Chapter 5 and 6 (i.e., from the interview, survey and bibliometric study) showed that researchers and publications in the field of OE are smaller compared to those found in the PHE; key researchers are getting old, younger ones are difficult to recruit, and these challenges are increasing over the years. Thus, based on the findings from all three phases, it was then argued that funding availability is one of the key drivers for the development (or lack of development) of OE as well as other scientific fields. Thus, exploring funding bodies' policies and funding decisions may further illuminate the data emerged from the earlier phases of the study, and clarify how and why these issues have occurred.

Hence, in the final phase of the study, the documentary review, issues that influenced the policies and decisions of funding bodies to support certain studies, researchers or fields

were explored. Five interwoven themes emerged from the documentary data that could explain how funding was allocated and on what basis. These themes were; the influence of key researchers and leaders in positions of power; internal and external policies; collaboration; technological development and evolution of new methods and techniques, and funding issues related to epidemiological studies.

The bibliometric study showed that collaboration and the use of new methods and techniques have contributed to the growth of PHE compared to OE. There is also evidence from the documentary review phase that these have been encouraged by funding bodies. Both collaboration and the use of new methods and techniques were less employed within the OE studies, which may have had negatively influenced the decision of funding bodies to support this field.

Another factor that may account for the lack of support for the OE field is that key OE leaders and researchers were less represented in the funding bodies' management, policy-settings and decision-making process. Thus, this field may have become less of a priority to these bodies. The documentary study has also shown that the key leaders and researchers within the funding bodies had influenced funding policies and decisions to fund certain research projects, programmes, and fields other than others. There is evidence that they are more likely to support areas of research similar to their own research areas and interests.

Furthermore, the majority of these key leaders and researcher came from industrial and clinical backgrounds or a combination of both. They were appointed largely on the basis that they had the background and ability to implement policies and projects that not only linked to improving the quality of life of the nation, but, more importantly, to promoting wealth creation through supporting research programmes that have commercialisation potential and economic return. Thus, internal and external funding policies in the UK, which have been based on the political, social and economic circumstance of the country, may have the greatest influence on the rise or fall of any particular health research discipline.

8.2 Synthesis and discussion of key findings

The section above summarised the main individual phases' findings. This section will consider the overall findings from all phases of this thesis and discuss these in relation to the context of OE field provided in chapter 2.

This research has found that there are several challenges facing the OE field, which originated from social, economic and political context in which OH field was constructed. The combination of these factors is contributing to the decline and fragmentation of this field. These issues are discussed next including; deindustrialisation, the exclusion from the NHS, and funding policies in relation to the auditing system of research within the UK higher education, and the trend toward a focus on efficiency and economic impact of research.

8.2.1 Deindustrialisation

The decline in the number of studies and researchers in occupational cancer may well be explained by the decline of traditional industries that posed risk to workers such as agricultural, mining and manufacturing industries. Furthermore, OE research has succeeded to significantly reduce diseases linked to heavy industries such as pneumoconiosis, and many of the classical occupational cancers and poisonings. For instance, the UK was the first to prohibit manufacturing of certain substances because of their carcinogenicity (e.g., beta-naphthylamine, benzidine, 4-aminobiphenyl, asbestos, and 4-nitrobiphenyl) through the Carcinogenic Substances Regulations in 1967 (Merletti et al., 2007). Once occupational hazards are recognised to causes diseases, they become subject to regulatory control, and hence particularly suitable for prevention. This is contrary to many aspects in PHE such as lifestyle risks (e.g., smoking and dietary habits), for which less imminent and more difficult to achieve controls are involved; such as modification of cultural and personal behaviours patterns.

The HSE additionally plays a key role in implementing preventative measures and controls in workplace environment through regulations, law enforcement and inspection of workplace. Therefore, occupational hazards could be perceived less of a problem, particularly due to the long latency of some of the occupational diseases (Rogers et al., 2009). This also may have influenced the perceptions of the government and other funding bodies that health and safety of worker and employees are taken care of by HSE. Thus, research in this area may have become less of a priority throughout the years of deindustrialisation and ongoing workplace environment improvements. Besides, funding bodies may not be interested in funding areas where health and safety legislations are in place.

As shown in chapter two (section 2.5.5.4), OH (and hence OE) was, in many ways, critically impacted by the progressive deindustrialisation process since the 1970s. Firstly, the deindustrialisation process and the resultant social and economic issues (e.g. unemployment, welfare state, poverty and health issues) contributed to health inequalities

(Black, 1980); these have since attracted public, researchers and policy makers attention (Marmot, 2001). The documentary review study showed how the government policies since the 1990s, particularly in regards to the 1992 White Paper 'The Health of the Nation' (DoH, 1992), has shifted the focus into issues of the wider public health.

This White Paper originated from the work of the Committee of Inquiry into the Future Development of the Public Health Function, chaired by Donald Acheson. The Committee report, *Public Health in England* (1988), reinforced 'Public Health' as the strategic function for the growing prevention agenda and public health medicine as the specialty. The *Health of the Nation* identified the key areas for preventive action as coronary heart disease and stroke, cancers, mental illness, HIV/AIDS, sexual health, and accidents. Epidemiological research has grown extensively within these areas in the public health domain as shown in the bibliometric study in the cancer area, but not with the OH field.

Secondly, with the decline of industries, OH provisions within these also weakened. Smaller industries, if included any provisions for OH, would contract-out these services. The implication of this was the lessening or worse eliminating the role of OH team within the industry management and the opportunities to promptly identify any new work-related risks or disease clusters (Guidotti, 2013). These issues would subsequently diminish the ability to conduct research studies, which could have been easier to conduct if the OH team is included within the management structure of the industry (Schilling, 1993). Furthermore, in house OH team may have a better opportunity to build surveillance systems and databases that could be utilised for research purposes and such teams may also facilitate access to workers and data within the industries of they are part.

Thirdly, trade unions played a major role in improving the provisions of OH as well as facilitated, supported and funded research studies within this area (Long, 2011; Wrigley, 1997). Besides, as Snider (1991) emphasised, the pro-regulatory forces, such as workers' unions, are important for the regulatory process since they are most likely to initiate in organised labour and that with persistent pressure and occasional crises, stronger laws and enforcement may be achieved. The decline in heavy industries since the 1970s, which was characterised by strong unionism (Griffiths & Wall, 2007), combined with the government's economic policies such as privatisation of such national industries had influence the density and strengths of trade unions (Wrigley, 1997). These issues also shifted the unions focus from occupational health issues to more pressing issues related to

job security and employment rights of the workers (Overell, Mills, Roberts, Lekhi, & Blaug, 2010).

Nonetheless, demographic changes of the population, globalisation and the changing world of work, new technologies, and new or increasing exposure to chemical and biological agents, carried new occupational health issues that require further research (Sas, Suarez, European Agency for Safety and Health at Work, & TC-OSH, 2014). The European Agency for Safety and Health at Work argues that these changes necessitate further research to understand how to adapt workplace design and work organisation to address the structure of the workforce of the future.

8.2.2 The exclusion from the NHS

The implication of excluding OH from the NHS on the field in general and OE in particular is vast. Occupational health issues are usually identified by occupational health physicians. Work-related health issues may not be easily identified by other clinicians. For example, new potential clusters of workers who are experiencing similar OH issues that possibly require urgent investigation could be missed when these workers have no access to OH physicians/services. Such workers are likely to seek medical help from various medical centres and different GPs, thus it would be more difficult for those GPs to recognise the possible links between workers' symptoms and their work.

Approximately one in twelve patients visiting their GP is seeking treatment or advice about work-related issue (Pearson, 2004). However, GPs' knowledge and experience of OH issues varies considerably and most of them received no formal training to deal with OH problems. In 2010, there were only 1100 GPs (1.8%) who held formal specialist training in occupational health (CfWI, 2010) out of a total of 59,733 GPs practicing in the UK (General Medical Council, 2016). Additionally, being excluded from the NHS, OH research is missing the funding opportunities from government funding bodies, charities, and pharmaceutical industries that are sponsoring research within the NHS. Furthermore, there is not a sufficient pool of workers/patients (except for NHS workforce) with work-related issues that could be recruited from the NHS to OE studies or to justify their funding from other sources.

Another challenge facing OH research comes from the diminishing medical workforce and the difficulty in attracting new doctors to specialise in this area, as discussed in chapter two. The first three phases of the study confirmed that the OE workforce is aging. In a workforce planning survey conducted by the FOM in 2011, the number of Members and Fellows of

the FOM was 687 (FOM, 2011). From those 457 (66.5%) members were 50 years old or older, giving a clear indication of the aging workforce within the OH field. The exclusion from the NHS means that consultant posts as well as speciality training opportunities are very few. This issue also threatens both the number of resources available for OH research and the control that OH researchers have over the research agenda.

8.2.3 Funding policies

Two key issues have influenced funding decision in terms of policy. The first issue is the auditing system of research within the UK higher education (i.e., the Research Excellence Framework (REF) and its predecessor the Research Assessment Exercise (RAE)). The second issue is the trend toward a focus on efficiency and economic impact of research. In this section both issues are discussed separately nonetheless it is important to note that both are interlinked and based on the neoliberal government policies established since 1970s as means of reducing the government public spending and increasing marketisation.

8.2.3.1 The impact of research assessment exercise on UK higher education

The drive for impact and user-focus in research discussed in chapter two has the potential to alter the relative positions of certain research fields within higher education. Fields with less immediate applications, such as OE, have to work harder to justify their research and teaching funding (Tapper, 2007). As found in this thesis, the impact of OE is low compared to PHE; judged by publication citations and the impact factors of the publishing journals. Furthermore, the research community itself acknowledged that it has been difficult to publish their studies in journals of higher impact. Harley (2002) identified a mix of positive and negative responses of RAE. The encouragement to publish research in high-rank refereed journals was perceived as a positive response to RAE. The key challenges of the application of the RAE process were in relation to the difficulties *'to the academic's traditional freedom to set their own research agenda, to produce the knowledge which they considered important, and to disseminate it in the way that they saw fit'* (Harley, 2002, p. 196). One of the justifications provided by some of the study participants for the lack of funding and publication in high impact journals was the lack of innovative methods employed in this field such as molecular and genetic techniques.

The Higher Education Funding Council's research assessment exercise that determines the amount of funds allocated to the UK universities is primarily based on peer reviewed scientific papers submitted for review from each university ('The Research Excellence Framework, 2014', n.d.). Moed (2008) shows that RAE has had influenced both HEIs and individuals researchers publication behaviours. In terms of multi-authorship, he found that

‘during 1997–2000, institutions raised their number of active research staff by stimulating their staff members to collaborate more intensively, or at least to co-author more intensively’ (Moed, 2008, p. 153). The bibliometric study confirmed this when it indicated that the number of publications with co-authorship increased in both PHE and OE fields over time, but that PHE showed higher rate of co-authorship contributions compared to OE particularly since the year 2001 (an average of 11.1 authors per PHE publication vs 6.2 authors per OE publication).

Furthermore, there has been a great pressure to publish and also a temptation to co-author papers without having made a substantial intellectual contribution, sometimes termed “gift authorship”. Particularly, it was found that a high statistically significant correlation was found between the RAE result and citation counts (Norris & Oppenheim, 2003). Besides, “gift authorship”, could also explain the increase trend of co-authorship (Kosmulski, 2012). Besides the research evaluation systems (e.g. RAE/REF) that pushes for as many papers as possible, there are other several reasons for granting a “gift authorship” (Bhopal et al., 1997; Psooy, 2010). The “gift authorship” of rebuttable, senior or successful authors could increase the chances of a research article being accepted by the targeted Journal, enhance its prestige and hence its success by increasing its citation frequency (Hinnant et al., 2012). Other cited reasons for “gift authorship” are; to boost the careers of novice researchers, to repay favours, to motivate research teams, maintain good relations or increase the chance of better assessment scores by senior colleagues (Bavdekar, 2012; Bhopal et al., 1997).

The bibliometric study indicates that about 50 % of the OE studies in the field of cancer were published in only two journals in the field of occupational health. The impact of this, in relation to REF, could be that such publications could have affected the amount of funding the department in which they were produced received (usually public health or epidemiology departments and occupational and environmental departments). Otherwise, lower impact studies could potentially have been excluded from the review if better studies from other groups were produced. In this regard, further research is needed to assess the number of OE publications that were submitted for the RAE/REF and what scores these had achieved, and whether the departments that include OE research received any funds as a result of the RAE/REF compared to other disciplines.

8.2.3.2 The impact of the policies focusing on efficiency and wealth creation

Snider (1991) noted that OH and safety is not necessary for the capitalist survival, and enforcement of OH and safety laws may be antithetical to capitalist interests because it may

be regarded as an attack on profitability. The government hence are most likely to create a symbolic effort to regulate (Snider, 1991). Fatal injuries hence are likely to cause the central problem for employers since these are instant, noticeable and may attract wider public sympathy, also they can be easily linked with a particular industry and working conditions. This trend was obvious in the reaction of the HSE to disastrous accidents (e.g., Bradford City stadium fire), which immediately investigated the issues and produced further reactive legislations. This is in contrast to work-related ill-health, which often has such long latency periods so that any particular company avoids effectively all responsibility for these; albeit that the cost of compensation for a limited subgroup of such illnesses may have ultimately to be endured by the government itself (Snider, 1991).

In this context, it is unsurprising that some industries refuse any research investigating such issues (as pointed out by some of this study participants), unless there is external pressure and a possibility that these health issues are more likely, in the near future, to be linked to the working conditions of these industries. This is when some industries would also support research; firstly, to be seen as doing something to solve the problems and secondly, to avoid possible future litigations. These issues were likewise emphasised and experienced by some of the key researchers interviewed in this study.

The decision to fund OE studies could be influenced by the ongoing improvement of occupational exposure control and preventative measures in workplace environment. Once occupational hazards are recognised to causes diseases they become subject to regulatory control, and hence particularly suitable for prevention. This is contrary to many aspects in PHE such as lifestyle risks (e.g., smoking and dietary habits), for which less imminent and more difficult to achieve controls are involved; such as modification of cultural and personal behaviour patterns. Funding OE research hence might have been of a lower priority throughout the years of ongoing workplace environment improvements. Furthermore, funding bodies may not be interested in funding areas where health and safety legislations are in place.

Furthermore, public policy in general and welfare systems in particular mimic markets in the search for economic efficiency and higher productivity (Popay, Whitehead, & Hunter, 2010). The marketisation policy encouraged consumerism, which lead to individualistic focus or trends (Barnett, 2010). The trend towards public health policies that focus on individual life style instead of population approach (as discussed in chapter 2) can also be partially explained by the interest of policy maker for a quick fix or “low-hanging fruit”

approach instead of long-term solutions. The implication of this is that a higher support for research that produces quick results that can be measured such as RCTs and other evaluations of interventions. This trend has also progressively reduced the interest and support for epidemiological studies particularly that of occupational in nature. To a degree, this is because most occupational risks are not individualistic in nature; i.e., occupational risks are not generally linked to life style, and workers mostly have no control on these. Pearce (1996) argued that the future epidemiology should restore the population perspective and appropriately use recent methodologic advances.

The literature shows that there are epidemiologists (primarily public health epidemiologists) who advocate for the use of new methods and techniques, such as molecular and genetics, in their studies (Axelson, 1994; Collins, 1998; Greenwald & Dunn, 2009; Ness et al., 2009), whilst others (mainly occupational epidemiologists), despite their acceptance of the importance of these, cautioned from the influence of their focus on individuals rather than population, which, for them, could deter epidemiology from its main purpose in relation to its benefits to public health (Pearce, 1996; Susser, 1999; Wegman, 2014).

This division between the two groups perhaps because the majority of OE studies are better addressed by population approach, which could also partially explain the lack of use of molecular and genetic approaches found within the OE field. Furthermore, OE studies require public policy support as well as employers' agreement and support, which can vary considerably between one employer to another and depend on the nature of the study. As the OE members, who participated in the interview and survey phases, pointed out, this can vary from a full support including funding, to a complete rejection of access to workers and data primarily for fear of litigations.

The documentary review also demonstrated how research funding policies has gradually encouraged and supported research agendas of potential economic benefits through commercialisation of research ideas and applied research that has economic impact. As discussed in the documentary study chapter, such neoliberal government policies were established with the publication of the 1993 White paper "Realising our Potential", in which the major emphasis were on user needs and partnerships between industry, government and the science base, for the purpose of creating economic power and wellbeing improvement. It encouraged initiatives for improving collaboration and links between universities, industry and government to promote the transfer of technology; greater innovation support to firms; contributing to wealth creation; improvements in the quality of life; and the

promotion of the public understanding of science (Great Britain & Chancellor of the Duchy of Lancaster, 1993). These themes, in particular wealth creation and quality of life improvement, were transposed into all of the main government funding bodies' mission statements (also indirectly into other types of funding bodies' aims), and continued to expand. Thus the pressure for a user-focus research has facilitated more powerful positions for applied subjects and multidisciplinary research fields (Brown & Carasso, 2013), such as clinical research and in particular RCTs.

The OE community also confirmed this trend when they reported that research funding has been largely shifting towards research that employed new innovative methods and techniques such as RCTs and that employed molecular and genetic techniques. In this thesis, these methods were found to be primarily linked to commercial applications and required multidisciplinary approach. Both, the use of such methods and collaboration, as a proxy of multidisciplinary, were less evident within OE compared with PHE. This could be because OE research has little or no practical and commercial applications compared to RCTs.

The OE researchers who participated in this study were critical of the stakeholders' higher level of interest in studies employing genetics and molecular methods, which have negatively influenced their support to current OE studies. Although these researchers did not employ such techniques in their studies, they did not criticise the use of these methods. As discussed above, this might be to some degree explained by the need for population approach rather than individual focus in OE. Another explanation of this lack of use of newer methods is the lack of training these researchers received, and another is the lack of collaboration with other disciplines that could bring this expertise into their studies. A closely linked aspect of research publication is collaboration. Reay (2004) argued that both research publications and collaborative links act as capital in academia. They are a form of social capital in that they are potential sources of information, and possibilities of influence; collaborations with high-status individuals within the field can be more valuable than collaborations with less well established individuals (Reay, 2004).

It is not clear though why they did not collaborate with such individuals/experts. It may be that they are still loyal to the old paradigms (e.g., the use of classical methods). In particular, the key researchers are few and come from the old school of thought, and the young researchers are few in this field and are mainly mentored by these key researchers.

More importantly, the training opportunities for OH in the NHS are very limited as discussed in the previous section.

Axelson (1994), pointed out that there are relatively few examples of OE studies worldwide that incorporated molecular and genetic techniques. According to Axelson, this is due to the high cost of collecting molecular and genetic data, and the need for establishing multidisciplinary teams covering the various technologies and methods in both molecular biology and epidemiology (Ness et al., 2009). Axelson (1994) suggested that since various exposed-worker groups are likely to be smaller in the future, any possibility to design more specific and sensitive studies should be utilised. He further anticipated that the application of epidemiologic tools to evaluate molecular biology data will therefore probably be interesting in OE in the future. Nonetheless, approximately 20 years later, OE researchers in the UK have rarely incorporated molecular/genetic techniques in their studies (2.7% of total studies in the cancer field) compared to PHE field (25.5% of total studies in the cancer field).

The ability of PHE to employ these methods could be partially explained by their access to and better links with the NHS, where all types of clinical research is conducted. Furthermore, the focus of the government policies on tackling public health issues and health inequalities has been more intense due to the economic and political cost that these issues impose on the government (Department of Health, 2010). However, the economic impact of OH issues is harder to measure, particularly as it is not included within the NHS remit, and industries and employers do usually contribute to the cost of this service.

Key international leaders in the field, however, cautioned from the distraction of using molecular and genetic approaches and advised for continuous use of classical methods (Pearce, 1996; Susser, 1999; Wegman, 2014). This issue was discussed by Wegman (2014, p. 740) as one of the challenges identified for OE in the 21st century, during the “2014 International Epidemiology in Occupational Health (EPICOH) meeting:

‘These exciting developments (referring to molecular and genetics methods) should not distract us from the ever-present need to explore and refine worker self-reports (represents a classical method) as valid measures of exposures and of illness. Self-reports are too often presented, if at all, with an apology for their use.’

This reluctance of the OE leaders (in the UK and abroad) to incorporate such methods should be addressed by the OE community, because these are linked to better funding opportunities and higher quality studies as revealed by this thesis. The implication of this issue and the overall thesis findings and recommendations are discussed in the next section.

8.3 Implications and recommendation

The findings of this research programme indicate that OE field is facing many challenges. The field has not been able to compete with other applied fields that get more support from policy-makers, universities, funders and researchers. The OE field contributed to our understanding of work-related exposures; some of these exposures may also exist in the environment. Therefore, OE contributed to both the working population and public health. Thus, this field is important and still needs to contribute to the health and wealth of the working population and the public. However, to maintain its future development, researchers in this field need to be aware of the issues discussed in this thesis and act collectively to face the challenges and uptake the opportunities. In the following sections, the implications of this thesis' findings are discussed along with some recommendations.

8.3.1 Reviewing the field and setting up research priorities

The substantial problems identified in this thesis are indicative of the lack of a strategic framework to decide upon priorities, relative roles or appropriate levels of support required within the field of OH. Although OE has contributed to the establishment of occupational health and safety, and improvements in the working population's health, participants in the first two phases of this research felt that it was no longer timely or adequate (Guidotti, 2000). The impact of new technological advancement in the workplace (e.g., the use of nanotechnology) and the changes on the type of work may cause unexpected work related illnesses (Coggon, 2005). Additionally, the population are living longer and, there is a global demand to increase the working age, though the good health of the working population is crucial to achieve that (Vodopivec and Dolenc, 2008). These issues open up the need for further OE investigations, which are currently identified as priority research areas in Europe (Sas et al., 2014).

These challenges have negatively influenced the quality and quantity of studies in this field, and affected the capability and capacity of its community members to carry out research projects in this important area. Furthermore, the OE community members see the lack of funding opportunities for research in this field as a major barrier towards conducting high quality studies. These issues have become disincentives for researchers to pursue important research questions in this area or to better understand the risks that workers are exposed to in the workplace and how these risks might be translated into the lower exposed general population, who may also be exposed environmentally. Thus, researchers might have left this important field into other areas of health-related research where there is more funding available.

The lack of investment in this area and in OH in general is clearly marked in the recent Black report 'Working for a healthier tomorrow' (2008b). She underlined that a £100 billion is the cost of ill health in the workplaces due to 175 million working days lost to sickness absence each year, 2.6 million people not working and receiving benefits because of a health issue, and other factors. Despite Black's review findings, the lack of interest in OH and research in this area continues with a the recent closure of the 'Health and Work Development Unit (HWDU), and its occupational health National Quality Improvement Programme' (Royal College of Physicians, 2014). This programme was established in 2008 (partly in response to Black review), which was a partnership between the FOM and the Royal College of Physicians (RCP) (funded by RCP). Its aim was to improve the health of the workforce through the; development of evidence-based guidelines, conducting of national clinical and organisational audits, and improvement of the implementation of NICE public health guidance for the workforce (Royal College of Physicians, 2015). The reason for the closure according to RCP is mainly because *'it has become impossible to sustain both the unit's and the programme's work in the current financial climate. For over a year the RCP has been supporting the unit with the shortfall'*.

The OE community and key leaders need to review the field's work, to identify achievements, failures, and to prioritise future issues that are most likely to affect the working population's health, and potential areas of research. In promoting policies that improve the wellbeing of the working population, the ability to set priorities and support correct decisions in occupational health and safety research is critical, particularly in the context of the current economic crisis. In order to strongly justify public and other sources of funding of occupational health and safety research, and the use of scarce research resources efficiently and effectively, there should be clear decisions about research priorities. These priorities have to be consistent not only with informed scientific opinion but also with relevant stakeholders' needs and national concerns within the broader policy context.

The Delphi technique has been successful in many countries for research priority setting of occupational health and safety (Iavicoli, Rondinone, Marinaccio, & Fingerhut, 2005), which can be utilised in the UK. The expert panel should include the stakeholders who are likely to be affected by the research, as well as the researchers themselves such as; expert from public, private and social bodies, occupational health and safety professionals, HSE, industries, trade unions, and universities. Furthermore, those experts should refer to whatever relevant primary and secondary data (e.g. HSE data sources discussed in chapter

2) to inform their decisions of research priority setting as well as considering the cost-benefit method (Anderson, 1994). For example; in 2014/15 stress, depression or anxiety and musculoskeletal disorders accounted for the majority of days lost due to work-related ill health (9.9 and 9.5 million days respectively out of a total of 27.3 million days (HSE, 2014). Therefore, research into these areas could be justified because of the cost impact of these on health of the working population and the cost to society. These issues were confirmed by a review of research priorities in the UK, which identified musculoskeletal and stress as two priority areas for research (Harrington, 1994; Harrington & Calvert, 1996); it ranked musculoskeletal issues higher than stress. However, this review should be updated in order to establish if any new issues have emerged and whether the prioritisation of musculoskeletal issues remains higher than stress-related issues.

Such organised review could persuade policy makers and funding bodies to increase resources to this field. Based on this comprehensive review, resources need to be directed to prepare and train young scientists to pursue research on these priority areas. They also need to be open to other theories and methods applied in other fields without losing the epidemiological focus of their studies and be open to develop their own theories and methodologies. This can only be achieved by being open minded and by careful planning and consultations with relevant stakeholders. Collaboration and multidisciplinary here will be vital in achieving this goal.

8.3.2 Education and training

The lack of universities' investment in OE was thought to be due to the lack of innovation in this field. The lack of use of 'trendy' methods such as molecular and genetic techniques, as a proxy for innovation, was the reason given by the study participants to this lack of investment. However, this lack of investment in OH in general was felt during the economic crisis in 1980s which coincided with the development of genetic techniques. Harrington and Seaton (1988, p. 1618) noted that *'in most British medical schools occupational health is given scant attention and in some it is not taught at all. Thus, the academic base for research into the subject has almost disappeared. Perhaps this is because occupational factors in disease are no longer thought important in an era that allows the human genome to be decoded'*.

However, the reason for the lack of universities' investment in this field could also be associated with the RAE/REF outcome. To survive, Universities would have to invest in fields that produced higher impact studies as per REF criteria, which are mainly based on the peer-review process, and on impact and bibliometric evaluation of the selected

publications and associated research programmes. However, this thesis indicates that the OE community was less likely to publish their studies in high-impact factor journals and the impact of their studies was lower than other epidemiological fields, at least in the cancer field and when measured by citation counts (which is not without limitations).

The initial impact of research and teaching auditing on the OH field was seen in 1989, when the University Grants Committee (UGC) (now HEFCE) commissioned a review of OH departments in the UK to examine current provision for teaching and research and to advise on the future pattern of provision (Waldron, 1989). The report of the review suggested that funds should be concentrated on only two centres of excellence, Birmingham and Aberdeen, while support for three other centres (Newcastle, Manchester and Surrey) should continue as before. Funding of Dundee would be withdrawn altogether. It also recommended that all funding for the OH department at London School of Hygiene be discontinued and its teaching posts and seven other posts should no longer be funded. This was shocking news for the OH community at that time particularly as the department was a worldwide distinguished teaching and research centre for occupational health (Engel, 1990; Waldron, 1989). Nonetheless, the department had suffered from financial and management crisis during the few years preceding the review and an internal review by the London School of Hygiene had already recommended the closure of OH department for financial reasons; a decision that was later withdrawn (Schilling & McDonald, 1990).

The discussion above indicates how the economic and political context in which OH teaching and research were positioned impacted on the field's development and hence on the wider issues of working population's health. The impact of this lack of investment on OH teaching and training is critical. Most people at work are not covered by occupational health services and hence a sick worker often seeks advice first from the GP or in an emergency from a hospital. Thus GPs and hospital doctors can play a vital part in identifying work-related illness which, for in some cases such as with drivers, their illness or disability may adversely affect the health and safety of the public. Therefore; as Schilling (1993, p. 420) recommended, teaching of occupational medicine should be an integral part of undergraduate clinical medicine, and that a '*Department of Occupational Health to be in an undergraduate medical school rather than in a school of public health*'. However, the current OH departments in the UK universities are independent units in peripheral fields attached to other more prominent disciplines such as public health and environmental health.

At the scientific level, it is important that the occupational health curricula are reviewed and to include varieties of methods and multidisciplinary approaches so that scientists from different disciplines could join this field. Research training should also include multidisciplinary approaches and skills. Training should be open to learning of new methods and techniques. This could be achieved initially by providing potential future researchers with opportunities to learn new skills from other disciplines whilst working within the field.

8.3.3 Contributing to policy

This study further indicates that OE is less engaged with policy makers and funding bodies as the OE community in general and the OE key leaders in particular are not visible within those bodies. This could be a reflection of position of the OH field in general. Harrison (Harrison, 2012, p. 591) concluded: *‘Occupational health in the UK is at a watershed. Should it embrace the public health agenda and engage with the developing national health economy or maintain an employer-led focus for its strategic development?....The time has come for a future forum for occupational health in the UK to develop a coherent and compelling vision and implementation plan that will secure the health and wellbeing of the working population’.*(Harrison, 2012, p. 591)

The generation of increasing evidence by epidemiology is of little consequence unless that knowledge influences policy and practice, in addition to improving understanding of aetiology and causal pathways. Epidemiology also needs to be applied to individual patient care in the assessment of risk at an individual level, tailoring preventive and therapeutic interventions as is increasingly the case in cardiovascular disease (Bhopal, Macfarlane, Smith, & West, 2011). Given that epidemiology needs to be relevant for policy, it needs to be presented in a meaningful way for policy-makers. This requires recognition of the different language used by epidemiologists and policy makers, as well as their very different timescales (Bhopal, Macfarlane, Smith, & West, 2011). Policy makers need to learn more about epidemiological strengths and limitations while epidemiologists need to understand the timescales and cycles in policy-making and political processes.

Ringen (1999, pp. 587–588) argues that the language used in research publications, which attaches humanity aspects with the data, can be a powerful motivation for change: *‘Research that holds out the consequences of our failure to prevent injuries and illnesses from occurring is a powerful stimulus for change. Prevention results from change, and change results from our ability to influence decision makers in industry, unions, and government. ... This is research that decision makers can understand. Statistical methods*

are important, but they are not an end..'

Wegman (2014) highlighted the key challenges of OE (worldwide) during the 21st century. One of the issues he discussed is the focus of researchers on research methods whilst focusing less on communicating the research implications and finding to the use of those colleagues in public health practice and policy-makers (Wegman, 2014). Key leaders, policy-makers and practitioners in OE need to develop strategies for widening their community and reinforcing the key messages about their discipline's approach towards public health benefits for instance via conference presentations to a wider group of disciplines, media engagement and involvement in national working groups. This would serve to raise its profile at sector and national level and potentially internationally.

The ideal situation for both, OH community and the UK workers, would be for OH to be included within the remit of the NHS. Industries and employers should contribute to an OH service but, ideally, the leading body should be the NHS. However, in the short term at least, this is not realistic. In the long term, this should be the aim of the OH community and stakeholders by working on priority setting and lobbying to influence policies. Key bodies that could potentially lead the movement to achieve this goal are the Health and Safety Executive, the Faculty of Occupational Medicine, and the Society of Occupational Medicine, which include OH practitioners and stakeholders from different backgrounds and from public and private sectors.

8.3.4 Further Recommendations

The audiences that will profit from this study include a wide range of stakeholders including OE researchers, researchers in other health disciplines, and policy-makers. In addition to the recommendations discussed in the previous section, other recommendations that are potentially transferable to other fields as well as OE will now be discussed.

1- Better communication

The participants in this research stressed upon the needs for collaboration with other disciplines, lobbying, and using innovative methodologies. They also recommended a more informed dialogue between OE researchers, the public, policy makers and the media to improve a better understanding of the relevance and importance of this field of research, and the work related risks in relation to health. The findings from this thesis also confirmed the importance of these needs in order for this field to sustain itself and develop in the future.

At the macro level, communication with relevant organisations and governmental bodies is important for the individual studies and for the field in general. However, it is important for the OE members, organisations, and university departments to improve communication and build communication channel between them. Schilling (1993, p. 417) believed that the isolation of an academic OH department can be fatal and advised such departments *'to maintain contacts within the university and with the industrial world outside'* in order to be able to fulfil its teaching and research commitment.

There should be an initiative to gather all of these groups and organisations to discuss the priorities, challenges and opportunities for this field. More importantly, they need to establish strategies to allow them to be involved in the development of related public health policies, and to lobby for improving their presence in the political arenas and related governmental bodies (e.g., funding bodies). Of course, this could also be done through conducting research studies and communicating the findings in a language that can be understood by policy-makers and the public. As Little (1998, p. 1144) explains:

'To give meaning to our science, we have to depart from science, and interpret what we have done in terms which have meaning to those who are the subjects of study, as well as to those by whom or for whom the study was done.'

Some of the means to improve communication and awareness of the importance of this field is through participating in scientific and non-scientific meetings and conferences. Representatives from the field should be chosen carefully to present their studies and their relevance to the scientific community, public and policy-makers. Another approach to communicating research findings is through publications in certain scientific journals. However, as shown by the bibliometric study, the findings of research in both OE and PHE (at least in the field of cancer) were concentrated (50% of the total publications) in only two journals within each field. Although this may indicate a publication pattern in all fields, OE and other relevant fields need to make conscious discussions to broaden their research dissemination. This should include publishing their research results more widely and in journals that more widely read and accessible by broader related stakeholders. Additionally, they could use other means of disseminations such as newsletters, relevant websites, and media reports etc.

2- Collaborations

The challenges of OE research in the UK, as highlighted by the findings of this thesis, may well be partially explained by the focus of its community on the research and research

process, and not sufficiently or clearly communicating the findings of their studies to other stakeholders. Examples of other relevant stakeholders include; policy-makers, funding bodies, employers, workforce, unions, and other colleagues in other health disciplines (e.g., clinicians, GPs, and public health practitioners).

McKeown (2013) believes that epidemiology lacks appropriate frameworks that shape the way in which to approach questions and the questions epidemiologists chose to investigate. It is argued that epidemiology has become a set of generic methods for measuring associations of exposure and disease in individuals, rather than functioning as part of a multidisciplinary approach to understanding the causation of disease in populations (Pearce, 1996). In the past, epidemiologists did not receive formal training in epidemiology. Instead they learnt from senior colleagues about different aspects of epidemiological, medical, and statistical approaches (Holland, 2002; Holland, Olsen, & Florey, 2007). This contributed to broadening their perspective in dealing with epidemiological problems.

Nowadays, however, epidemiologists come from different backgrounds and fields; their commonality is the relatively standardised epidemiological methods training. Researchers in any academic discipline tend to cluster into informal networks, or invisible colleges, which focus on common problems in common ways (Price, 1986). It is likely that each group will participate in solving epidemiological issues from their own fields' perspectives, and may not necessarily be involved in decisions that require other practitioners' input. For example, statisticians might only be involved in one aspect of the study (e.g., analysis), whilst a physician might be involved in identifying the research question and recruiting the population to be studied. Thus, each group might not have full oversight of the broader issues of the problem under investigation.

Multiple determinants of disease approach requires multidisciplinary (Remington & Brownson, 2011), and thus collaborations between researchers from different disciplines is necessary. In this research, this issue was more evident in the OE field than other epidemiological fields. McKeown (2013), in order to overcome the limited theories in this field, encouraged epidemiologists to reframe the perspective of epidemiology and broaden its methods by becoming more open to multidisciplinary approaches (McKeown, 2013).

Collaboration henceforth is vital for the future of OE. Collaborations and the use of new methods are interlinked. Additionally, funding bodies encourage collaborations by supporting studies that demonstrate high level of collaborations. The results from this thesis

strongly supports this argument as well as other studies (Braun, 1998; Defazio et al., 2009). OE researchers should be open to collaborate with other scientists from other fields who could bring new insights and expertise to the study. OE should not work in isolation from other public health disciplines, which would only cause further isolation and challenges to the field. Its importance is rooted in its public health contributions. Thus, researchers should take every opportunity to participate and be involved in collaborative studies examining the ill-health and injuries from different prospective using different approaches.

The OE community should explore possible additional data sources for conducting high quality OE studies. Such sources can be from the OH field itself, NHS data, and from other epidemiological data sources. One way of identifying potential data sources is by surveying the relevant literature, researchers, and organisations. There are potential data banks (for example the Million Women Study and the Whitehall cohort) available that could be exploited to answer questions related to the working population. Such data banks should be identified and exploited in this field. Collaboration in this context is necessary and may only require the OE researchers to approach scientists who are already working in these areas to facilitate the process. Furthermore, HSE collects different types of data and holds various sources of information. Such data and sources could also be exploited by the OE scientific community in collaboration with the HSE scientists and researchers.

Collaboration with industry is another area in which OE is lacking. This, however, may be difficult to achieve because OE studies are unlikely to lead to ideas for commercialisation. On the other hand, this could potentially be possible if OE participates in collaborative studies which are multidisciplinary in nature. Further thinking and innovative ideas are needed in this regards from the OE community members.

3- Recommendations for policy-makers

Policy-makers should be aware of the impact of their decisions on each field and its contribution to the public health. Funding policies should not only focus on the immediate or measurable economic return from research studies. OE studies may not necessary provide visible or immediate economic return; however, the contribution of its studies may have long term public health and economic benefits (Robertson, 2015).

Policy-makers should also be aware of the role of key researchers and leaders in driving certain research areas, particularly those who are involved in making funding decisions and the impacts of their decisions on other fields and on the health of the public.

8.4 Areas of future research

There are a number of ways in which the work presented in this thesis could be progressed. In all these propositions the findings presented in this thesis can be used as preludes to illuminate further work in each of the forthcoming potential research areas.

8.4.1 Further explorations of issues influencing the development of health disciplines

The analysis of key documents published by key funding bodies highlighted some important and pertinent issues in terms of funding decisions and policies and important factors that influence these. It would be also valuable to review the annual reports of relevant funding bodies for recent years (2000-2015) and compare the findings to those of the period evaluated in this study. For example there are similarities between these eras, most importantly both had periods of economic recession (in 1980s in this study, and since 2008 in the proposed period). The findings of this analysis can be used as a framework, in addition to exploring any new factors that might have possibly emerged in later years.

In addition, it would be valuable to conduct a case study of different and recent successful research programmes in different research disciplines. As a starting point, the findings of this thesis can be used as a framework. In particular, issues surrounding the inceptions of the ideas of these programmes, what approaches the teams (or certain individuals) utilised to get support from different stakeholders (e.g., funding bodies, collaboration from other institutes/bodies, key leaders or individual researchers, research subjects), and who they regarded as the most influential in the programme success. Another issue that could be explored by using this method is the identification of practical challenges and how some teams were successful in overcoming them.

Further exploration of the role of funding bodies could be extended by identifying those leading experts who contributed to the decision of funding these projects. This is to examine their perspectives and background information on how funding is allocated and who and what influence this decision, as well as whether research in occupational health is valued compared to other fields. This can be investigated in the context of the case study either by interview or survey methods, and supplemented by documentary analysis. The key informants can be identified from the documentary analysis. This is an important and feasible approach, particularly as some of key informants might still be active in their roles or contactable if retired.

Collaboration was also identified as one of the key criteria for research success in this thesis. Similarly, this could be investigated further in the context of these case studies of successful research programmes. Comparing the findings from each case study of successful programmes will shed more light on general and specific aspects, such as social, economic and political issues, that influence the development of different fields. Such studies may not necessarily focus on a particular field, but on funding policies and decisions in health research disciplines in general or any other area of interest. Researchers and policy makers can potentially benefit from the findings. For researchers, they could become better informed of such issues and use the study findings to improve communications with relevant stakeholders and thus improve their chance of developing their research areas. Policymakers could become better informed of the influence of their policies and other factors on the distribution of funds to scientific fields, and, particularly, the likely impact of these decisions on the society, economy, and future development of certain scientific fields.

8.4.2 Further bibliometric analysis

The bibliometric study (phase 3) provided evidence about the characteristics and the size of the OE compared to the PHE in the field of cancer. It would be interesting and valuable to explore these issues in a newly emergent area in the fields such as musculoskeletal, stress or mental health. Although the earlier phases of the programme of research showed that the OE field is small regardless of the areas of focus, nonetheless it would be valuable to know the characteristics and the growth rate of publications of new areas in this field, and whether these are growing in a similar pattern to that found in cancer epidemiology. This includes finding out whether other researchers from other fields contribute to these areas. The results of such investigations, along with this study's findings, could be beneficial for identifying the areas of research gaps and thus redirecting funding and research efforts to these areas.

8.4.3 Barriers to OH speciality training

Despite the efforts of FOM to encourage medical students to enter the OM specialty, there has been steady decline in the number of doctors entering OM. It is also acknowledged that many of the doctors specialising in the field of OH come from other specialities or from general practice. In light of this, FOM should not only target medical students or new graduates in their efforts to improve speciality training recruitment, but also should target doctors in other specialties. Research is hence needed to identify and explore the obstacles that prevent medical students and newly graduates from entering the OH specialty. This is particularly important because the continuous efforts of the FOM have not been successful in this matter. Such research could shed some light into the possible reasons for their reluctance and possibly identify strategies that may improve the image of OH field and thus

improve the recruitment into the speciality. This is potentially a fruitful area for further research.

8.5 Strengths and limitations

This section focuses on the strengths and limitations of this study. The following discussion will help develop a critical understanding of the findings in this study. The first part presents the study strengths followed by a discussion of its limitations.

8.5.1 Study Strengths

This study employed a pragmatic approach using a sequential, exploratory, mixed-method design. The main aim of using this approach in this study was to explore challenges and facilitators of the OE research in the UK, and to suggest recommendations for future development in this field and other similar health research disciplines. The innovative application of mixed-methods in this study was necessary to address the complexity of this topic. This led to obtaining a more comprehensive understanding about the topic and increasing the validity and reliability of the research results, particularly since the qualitative and quantitative phases were complementary to each other. Quantitative and qualitative research methods examine and explore the different claims to knowledge and both methods are designed to address a specific type of research questions (Creswell, 2009). The advantages for using mixed-methods approach were that the qualitative data and their subsequent analysis allowed the researcher to explore and better understand the complexity of a phenomenon (Bergman, 2009), and provided in-depth understanding of the research problems and exploration of views; the quantitative data then provided more objective measure of reality (Creswell, 2009), using statistical results on key issues for larger numbers of participants.

Second, a novel approach of undertaking a bibliometric analysis was developed. The novelty of this approach sets in the completeness and volume of publication data it draws on, and the level of detail included about researchers and their institutions. Additionally, the way in which this approach was undertaken within a health research field is systematic and unique, which can be employed to systematically study the characteristics of other health research fields.

The bibliometric study was unique, its originality lies in the completeness and volume of publication data it draws on, and the level of detail included about researchers and their institutions. A combination of different databases was used for different purposes; to identify relevant study in a systematic way (Medline), to collect bibliometric data (WOS),

and to efficiently extract relevant bibliometric data for analyses (Histcite). Again, to the author's knowledge, this approach has never been tried before. This approach allowed comprehensive exploration of both the OE and the PHE fields.

In addition, this bibliometric study advanced our understanding of the level of growth of OE compared to PHE over time by investigating the characteristics of their literature, and introduced an innovative method of investigation to health research fields for the first time. This study employed a comprehensive search strategy, and an extensive manual checking and verifications of the search results. Moreover, the bibliometric study explored further key issues identified in the previous phases, which were surprising and not fully confirmed or understood. Subsequently, this method not only confirmed some of the key issues (e.g., the small size of the OE community and publications, lesser utilisation of new methods and techniques, and the low level of collaborations compared to PHE), but also elucidated them and provided key areas that merited further consideration (funding issues), and which were explored in a subsequent phase.

Thus, this mixed-method design in this context, to the author's knowledge, is unique and has helped to fully address the key issues under investigations from different angles using qualitative and quantitative studies. The decisions taken about research questions, research designs and analytical methods in this research programme were not arbitrary, but necessary steps to understand the root of the challenges and facilitators of the OE research, and to make a significant contribution to knowledge for the health research community.

8.5.2 Study Limitations

Sample selection and non-response biases

No sampling frame was available, in the survey phase, from which to select active UK-based OE researchers. Therefore, several approaches were used to identify as many potential participants as possible (i.e., the target population). This included approaching all UK-based delegates who attended EPICOH conference (held in Oxford September 2011); snowball sampling by asking these delegates to identify other subjects and online screening of the delegates' organisations for other potential participants; and from the literature review and searching the internet. A large proportion of UK-based OE researchers from most, if not all, key relevant institutions attended the conference, yet it was not possible to ascertain if they were representative of the target population. The characteristics and motivations of the survey non-respondents; therefore, could be different from those who responded. It might be possible that the participants who responded regarded this research topic as an important, or experienced more challenges (e.g., by having longer experience in

the field) than the non-respondents, and thus had something to say about the topic. Additionally, it was not clear whether the non-respondents would have identified any other issues not reported by the respondents.

Therefore, if less experienced, or those who had not encountered challenges were excluded or less likely to respond, then the study sample could have been less representative of the targeted population. In this case, the reported challenges and facilitators may have been overestimated in this study, which should be taken into account when generalising the study findings.

Another approach that could have been utilised to get a better representation and probably targeting a wider group of OE researchers would be through contacting participants via the Faculty of Occupational medicine (includes medical practitioners membership) and the Society of Occupational Medicine (includes medical and non-medical professionals membership). Not all members of these two bodies are research active and it is difficult to know this information. Nonetheless, this issue could have been explained in the questionnaire cover letter. In future surveys of OH professionals and researchers this approach is recommended.

Bibliometric study limitations

Bibliometric data have some drawbacks (Hood & Wilson, 2003). There are many challenges in relation to data level including spelling differences and errors, inconsistencies related to the indexing of subjects, multiple ways of presenting authors' last names and initials, changes to journal titles, date inconsistencies, and inconsistencies with institutional affiliations. To alleviate this, all data retrieved were manually checked for inconsistencies and errors. Additionally, there may be bias in the data due to the coverage of journals included in a database, incomplete historical data beyond a certain period of time, delays between publication and abstract indexing, changes in policies and practices, and standardisation routines that alter data. However, the database used in this study, MEDLINE, is considered one of the most exhaustive databases in the biomedical field (Falagas et al., 2008).

On the other hand, Ugolini et al. (2006) points out that the difficulty of retrieving literature of newly-established epidemiological disciplines (e.g., molecular and genetic epidemiology) and suggested a search strategy that combine keywords and MeSH terms. They conducted a bibliometric study using MEDLINE to evaluate and compare the scientific production of

molecular and genetic epidemiology in the field of cancer between countries (Ugolini et al., 2006). They found 295 studies published from the UK between 1995 and 2004. In this period within this study (i.e., excluding the period before 1995 and after 2004), 133 publications were found, which represent 45.1% of the total articles found in Ugolini and colleagues study. In their study, they employed a complex search strategy using both MeSH and free text terms (e.g., chromosome aberrations, micronucleus test, polymorphism, genetic, genotype, etc.), which was not possible to employ in this study. A more general MeSH and free text terms were employed (e.g. epidemiology {MeSH}, neoplasms {MeSH}, UK {MeSH and free text}) to avoid bias to a certain field in epidemiology. Additionally, it would be impossible to identify and use all key words in all epidemiological fields in cancer. Despite efforts to identify all eligible published studies, one cannot exclude the possibility that some were missed. This is because of the diversity of epidemiological designs, the absence of standardised terminology, and the limitations of keywords or MeSH searches (Peersaman, Harden, Oakley, & Oliver, 1998). Therefore, the figures should be viewed in the context of the overall picture of each field, rather than in absolute terms.

Notwithstanding, Ugolini and colleagues (2006), more likely, overestimated the number of the studies in the UK. They grouped papers from England, Scotland, Northern Ireland and Wales under the heading UK without manually examining that these publications are in fact from the UK. Whereas, in the current study, all publications were checked manually and independently, and many studies thought to be; from Wales were found to be from New South Wales (a state in Australia), and from Northern Ireland were found to be from the Republic of Ireland, which were subsequently excluded from the study. Furthermore, the authors considered the country of the first author for their calculations; however, the study might have not been conducted in the first author's country.

8.6 The generalisability and transferability of the findings

Although the findings of this thesis can generally be widely applicable to the OE field, one must be careful when generalising the findings to all subfields of the OE, particularly those that are newly emerging such as those investigating work-related musculoskeletal and stress issues. Although to some extent researchers from all subfields were included in the survey phase, some of them might have not been identified (and thus excluded), particularly if they regarded themselves to belong to other fields such as psychology or musculoskeletal fields.

The bibliometric study focused on the field of cancer, and the documentary review was, to some degree, restricted to the cancer field too, as one of the three included funding bodies was a body that support cancer research only (CRC). Therefore, there was a deliberate focus

towards the field of cancer. It is possible therefore, that new or different issues might have emerged if other fields or funding bodies were included, particularly for issues that are currently emerging in the OE field.

Furthermore, the study provided useful insights for health disciplines about the issues that influence the field development using OE as an exemplar. The findings may not all be applicable to all fields, but some will undoubtedly be transferrable and helpful to some fields (particularly epidemiological or similar fields). If challenges and facilitators of such fields are sought, these research findings can be utilised as a framework which can be modified or built on based on the field of investigation and its context.

8.7 Conclusions

Owing to its comprehensive and multi-perspective design, this was a unique mixed-method study investigating the challenges of and facilitators of OE research in the UK and their implication on the field's development as well as having some applicability to other health research fields. This pragmatic study has filled a research gap that existed through placing micro- or individual-level issues that the OE field is currently facing within a broader context of political, social, and economic factors, as well as other epidemiological and health research fields.

The rise and fall of a scientific field is not largely based on its academic and scientific achievements and discoveries; social, economic and political factors play key roles in the development (or lack of development) of a scientific field. As this thesis demonstrates, the current limited development of OE in the UK has been influenced by a complexity of interactive causes, which originated from economic, social, and political factors. These factors include; the deindustrialisation, the exclusion of OH from the NHS, and certain government policies particularly in relation to the focus on economic return and efficiency of scientific research, and the research auditing process at higher education institutions.

Hence, a scientific field that engages in social, economic and political matters; that is open to new advances in research; and that optimises networking opportunities with other disciplines, key researchers, policy-makers and other related stakeholders and institutions, has a better chance of success and development. In this context, the role of key leaders in a scientific field is crucial. They are the ones who could potentially represent their field in the wider political and scientific arenas. Thus, it is important that they contribute to building communication channels by understanding the different languages of different groups in these arenas, as well as improving their aptitude to translate the language of their specific field to other groups or communities.

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10 APPENDICES

Appendix A-1: Qualitative study participants information sheet

University of Central Lancashire
Preston
Lancashire
PR1 2HE
Tel: +44 (0)1772 201 201

Perceptions of the Barriers to and the Facilitators of Occupational Epidemiology Research in the UK: A Mixed Method Approach

Research participant information sheet

Name of researches: S Sweity, C Sutton, D Dedman, S Downe & D McElvenny

Dear researcher,

You have been identified by Prof. Damien McElvenny as being an important U.K. based researcher in the field of occupational epidemiology. Therefore, we are inviting you to take part in a research study. This study is the first phase of a larger PhD programme, which will be carried out in three phases. Please read the following information, and take time to decide whether or not you wish to take part.

What is the purpose of the study?

I am a PhD student at the School of Health, University of Central Lancashire, and I am supervised by four experienced researchers. My research is looking at the barriers to and facilitators of occupational epidemiology research in the U.K. The main aims of this study are to identify and analyse barriers/facilitators of occupational epidemiological research studies in the U.K. and strategies developed to strengthen the facilitators and minimise the impact of the barriers, and to evaluate the effects of the identified issues on such studies, and on the interpretation of the findings.

Why have I been chosen?

You have been identified as a key researcher in the field of occupational epidemiology in the U.K. I hope to interview key researchers to explore their views and experience of these issues. If you agree to take part I would like to discuss your views on this topic and if possible to provide any references or materials

you think it may be useful for the research. The interview will take place between May 2011 and September 2011, on a mutually agreed date and time, and will take approximately 60-90 minutes.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. This includes being able to withdraw any unprocessed data previously supplied.

Will my taking part in this study be kept confidential?

Interviews will be recorded and fully transcribed. The digital recordings and the transcript will only be accessible to members of the research team, and will not be used for any other purpose. They will be kept securely, in strict accordance with the data protection act and the University guidelines. They will be destroyed five years after the end of the project. In the transcript the names of the participants as well as those people and organisations you mention will be changed so they will not be identifiable. However, because you are a prominent researcher in your field, it is possible that you could be recognised from your comments. We will therefore seek your permission before using any direct quotes in the final reports and publications. You will be offered a copy of your interview transcript. If you wish to do so, you can take out or amend any part of it that you do not wish reported in the findings. You could also choose not to use any of your interview quotes that cannot be anonymised in any reports or publication.

What will happen to the results of the research study?

As well as being of considerable academic interest, the results of this phase of the study will be utilised to produce a useful framework to facilitate the conduct of health research, with a focus on the field of occupational epidemiology, and reduce the possible hurdles and their impact upon such studies. A summary report will be circulated to all interested participants or participating organisations. Please indicate on the consent form if you would like to receive a summary of the results.

Who is organising and funding the research?

The PhD is a studentship which is funded jointly by the University of Central Lancashire, and the student.

Who has reviewed the study?

The study was reviewed and approved by the Faculty Ethics Committee at the University of Central Lancashire. It was also reviewed by the University Research Degree Subcommittee.

Contact for Further Information

If you have any questions concerning the research or if you would be interested in taking part please contact me and I will arrange for the interview at your convenience.

Samaher Sweity, Tel: 07958227118, e-mail: ssweity@uclan.ac.uk

Or contact the student's lead supervisor for any query or complaints

Dr Chris Sutton

School of Health

University of Central Lancashire
Corporation St
PRESTON
PR1 2HE
Tel: (01772) 892783
E-mail: CJSutton@uclan.ac.uk

Thank you for taking the time to read this and if you do agree to take part in this study thank you for your involvement.

Appendix A-2: Consent to Participation in qualitative study

Perceptions of the Barriers to and the Facilitators of Occupational Epidemiology Research in the UK: A Mixed Method Approach

Consent to Participation in Research

Please read each statement carefully and initial each box then sign at the end of this form.

Please Initial Box

1. I confirm that I have read and understood the information sheet dated April/2011 (version 1) for the above study.
2. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reasons.
4. I agree to the interview being digitally recorded, and for the researcher to take hand-written notes.
5. I understand that the digital recording of interviews will be destroyed at the end of the project
6. I understand that information I provide such as details of a particular study, and names of organisations and people will be kept confidential and replaced by pseudonyms.
7. I agree to anonymised quotes from my interview being used in reports and publications. I understand that if it is possible that I could be identified from quotes, I will have the opportunity to check them prior to publication.
8. I understand that the data I provide will not be used for any other purpose or released to others without my written consent.
9. I agree to take part in the above study.
10. I would like to receive a summary of the results when this project is completed.

Please complete this section after the interview.

The researchers will make every effort to anonymise any quotes included in any report or publication. However, this may not be possible in all cases; therefore, please chose one of the following options by initialling the box:

- I agree for any quotes to be used; even if I or my organisation could be identifiable.
- I would like to review the quotes that cannot be anonymised from my interview before dissemination, and agree to be contacted again for that purpose.
- I do not wish for any of my quotes that cannot be anonymised to be used in any reports or publication.

Name of participant Date Signature

Name of person taking consent Date Signature

Appendix A-3: The study questionnaire cover letter

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Survey of the Perceptions of the challenges and the Facilitators of Occupational Epidemiology Research in the UK

Name of researchers: S Sweity, C Sutton, D Dedman, S Downe & D McElvenny

Dear colleague,

I am a research student at the University of Central Lancashire. I am examining the challenges and the facilitators of occupational epidemiology research in the UK. The data collected will help me to provide useful recommendations to facilitate the conduct of health research, with a focus on the field of occupational epidemiology.

Because you are an active researcher/stakeholder in the field of occupational epidemiology, I am inviting you to participate in this research study by completing the attached short survey.

The following questionnaire will require approximately 15-20 minutes to complete. In order to ensure that all information will remain confidential, please do not include your name. Your participation is voluntary, and returning the completed questionnaire will indicate your willingness to participate in the study.

If you choose to participate in this project, please answer all questions and return the completed questionnaires to the drop box located at the registration desk at the EPICOH conference/ by mail in the provided stamped envelope. Please note that there is no recompense for responding.

The results of this study may be published, but your responses will be treated with confidence and at all times data will be presented in such a way that your identity cannot be connected with specific published data.

If you require additional information or have any complaints, please contact me or my study lead supervisor using the contact details listed below.

Dr Chris Sutton, School of Health, University of Central Lancashire, Corporation St, Preston, PR1 2HE, Tel: (01772) 892783, E-mail: CJSutton@uclan.ac.uk

Thank you for considering taking part in this study.

Yours sincerely,

Samaher Sweity, Tel: 07958227118, e-mail: ssweity@uclan.ac.uk

Appendix B-1: Thematic analysis process of the review data

Barriers themes, 1 st iteration	Facilitators, themes 1 st iteration	Impact	Themes, 2 nd iteration
Missing information/data. Unavailability of data about the study population.	The availability of information sources such as well-established databases, surveillances registries of relevance, and governmental institutions (e.g. THOR network, Office of National statistics, death registry).	selection bias due to differences in included and excluded participants	Methodological issues: <ul style="list-style-type: none"> • Missing data/information. • Study design appropriateness. • Advancement of statistical methods • Low participation/recruitment rate
Study design did not allow robust conclusions of the causal association	Advancement of computers led to proliferation of statistical analysis methods.	Reduction in the sample size, weakening the statistical power due to confounding, and limiting analysis	Resources issues: <ul style="list-style-type: none"> • Information/data sources. • Previous large studies as a source for new studies • Sample size availability • Occupational health system in place.
Low participation/response rate	Well established cohort and other large epidemiological studies as a source for further sub studies, and data analysis based studies.		Practical issues: Recruitment/ response rate issues. Communication with relevant stakeholders.
	To develop strategies to improve response/recruitment rate		
Small number of participant available	Appropriate design to answer the study question	Design did not allow complex analysis, making it harder to draw firm conclusions.	
Difficulties in recruiting participant due to the way their work is organised.	Managers Agreement for the study to be carried out. Good communication between researchers and managers including clear and detailed agreement in relation to the study procedures. Study topic is of interest to the managers, and can serve their goals/agenda.		
Lack of registries that can be exploited as a sampling frame	Full application for ethical approval was unnecessary		
Inaccuracy of the information	The use of fully anonymised data and records		
	Comprehensive occupational health system in place		
	High response rate		

Appendix B-2: List of journals included in the review

Journal Name	No. of occupational epidemiological studies conducted in the UK
OCCUP ENVIRON MED	8
OCCUP MED-OXFORD	20
INT ARCH OCC ENV HEA	1
J OCCUP ENVIRON HYG	no relevant studies found
J OCCUP ENVIRON MED	2
J OCCUP HEALTH	no relevant studies found
ANN OCCUP HYG	3
INT J OCCUP ENV HEAL	no relevant studies found
SCAND J WORK ENV HEA	no relevant studies found
American Journal of Industrial Medicine	1
CANCER EPIDEM BIOMAR	0
Cancer Epidemiology	no relevant studies found
EPIDEMIOL INFECT	no relevant studies found
EPIDEMIOL REV	no relevant studies found
EPIDEMIOLOGY	no relevant studies found
GENET EPIDEMIOL	no relevant studies found
INT J EPIDEMIOL	no relevant studies found
J CLIN EPIDEMIOL	no relevant studies found
J EPIDEMIOL	no relevant studies found
J EPIDEMIOL COMMUN H	2
J EXPO SCI ENV EPID	no relevant studies found
NEUROEPIDEMIOLOGY	no relevant studies found
OPHTHAL EPIDEMIOL	no relevant studies found
PHARMACOEPIDEM DR S	no relevant studies found
SOC PSYCH PSYCH EPID	1
AM J EPIDEMIOL	no relevant studies found
ANN EPIDEMIOL	1
EUR J PUBLIC HEALTH	no relevant studies found
American Journal of Public Health	no relevant studies found
J PUBLIC HEALTH-UK	no relevant studies found

Appendix B-3: Phase two search eligible articles characteristics

Title	Journal Name	Actual study date/data collection	Study design	Population
Rewarding and unrewarding aspects of deployment to Iraq and its association with psychological health in UK military personnel. Sundin et. al.	International Archives Of Occupational And Environmental Health	Not mentioned /2003- 2006.	Analysis of data from a TELIC cohort study.	5,573 UK military personnel who had deployed to Iraq
Social mobility and social accumulation across the life course in relation to adult overweight and obesity: the Whitehall II study. Heraclides and Brunner, 2010	J Epidemiol Community Health	Not mentioned / 1997-1999	Cross-sectional analysis of data from Whitehall II cohort study	4598 participants (44-69 years).
Work disability following major organisational change: the Whitehall II study. Virtanen et. al. 2010	J Epidemiol Community Health	Not mentioned / data collected from 1991-2001	Data from the prospective Whitehall II cohort study.	The analytic sample comprised of 4682 London-based office staff aged 39-62 years.
The effects of age and shiftwork on perceived sleep problems: results from the VISAT-combined longitudinal and cross-sectional study. Tucker et. al. 2010	Journal of Occupational & Environmental Medicine	Not mentioned /1996, 2001, and 2006	Longitudinal data collection	Employees who were 32, 42, 52, and 62 years old in 1996.
Work-related mortality in England and Wales, 1979–2000. Coggon et. al. 2010	Occupational and Environmental Medicine	Not mentioned /1979-2000 excluding 1981	Proportional analysis of mortality by occupation over a 22-year period, data from The Office for National Statistics	deaths cases in men aged 20-74 years during 1979-1980 and 1982-2000 with a recorded occupation

Organisational justice and markers of inflammation: the Whitehall II study. Elovainio et al. 2010	Occupational and Environmental Medicine	Not mentioned / 1985-1993 and 2003-2004	Analysis of data from the prospective Whitehall II cohort study	3205 men and women
Justice at work and metabolic syndrome: the Whitehall II study. Gimeno et. al. 2010	Occupational and Environmental Medicine	Not mentioned /1985-2004	Analysis of data from the prospective Whitehall II cohort study	6123 participants (59% of the original cohort)
Do pre-employment influences explain the association between psychosocial factors at work and coronary heart disease? The Whitehall II study. Hintsä et. al. 2010	Occupational and Environmental Medicine	Not mentioned /1985-1999	Analysis of data from the prospective Whitehall II cohort study	6895 men civil servant
Cause-specific mortality in British coal workers and exposure to respirable dust and quartz Miller and MacCalman, 2010	Occupational and Environmental Medicine	Not mentioned / 1959- 2006	New analyses of the mortality within the PFR cohort	Cause-specific mortality in a cohort of almost 18000 men from 10 British collieries.
Trends in blood lead levels in UK workers, 1995–2007. Morton et. al. 2010	Occupational and Environmental Medicine	Not mentioned /1995-2007	Data form routinely collected and analysed blood samples	20899 blood results from 8810 workers in 972 companies
Occupational exposure to polycyclic aromatic hydrocarbons and lung cancer risk: a multicenter study in Europe. Olsson et. al. 2010	Occupational and Environmental Medicine	Not mentioned / 1998-2002	A case control study.	All newly diagnosed lung cancer cases (age <75 years) in the participating hospitals. Population controls were selected from the general practitioner registry in Liverpool. A total of 2852 lung cancer cases and 2923 controls (including participant from UK)
The incidence of medically reported work-related ill health in the UK construction industry. Stocks et. al. 2010	Occupational and Environmental Medicine	2002-2008	Analysis of data from THOR network	over 2000 physicians reported to THOR 28068 actual case reports of WRI from construction industry workers

Occupation and mortality related to alcohol, drugs and sexual habits. Coggon et. al. 2010	Occupational Medicine	1991–2000	Analysis of data from The Office for National Statistics	Data on all deaths at ages 16–74 years in England and Wales
Needle stick injuries during surgical procedures: a multidisciplinary online study. Adams et. al. 2010	Occupational Medicine	Not mentioned	Survey questionnaire	136 staff in a NHS trust who took part in operations
Assessment of respiratory health surveillance for laboratory animal workers. Allan et. al. 2010	Occupational Medicine	Not mentioned /2004-2005	A retrospective review of surveillance records held in (OH) case notes and survey of the current workforce.	87 laboratory animal workers
The Management Standards Indicator Tool and the estimation of risk. Bevan et. al. 2010	Occupational Medicine	2009	Cross-sectional questionnaire survey	3579 workers from London Area of Her Majesty’s Prison Service (HMPS)
Management of blood and body fluid exposures in police service staff. Dunleavy et. al. 2010	Occupational Medicine	2007	Data were collected on the circumstances and the post-incident management and forwarded to an expert panel to review the post-incident management provided by OH.	105 proformas were forwarded to the research team.
Comparison of various airflow measurements in symptomatic textile workers. Fishwick et. al. 2010	Occupational Medicine	Not mentioned /1989-2000	Retrospective analysis of data collected as part of a large epidemiological survey of textile workers. A control group of asymptomatic subjects matched for age and gender was also recruited.	1766 workers, of whom 1547 (88%) completed a study questionnaire. Of the 179 workers, who complained of at least one work-related respiratory symptom, 84 workers had further physiological measures made in the workplace, and 84 controls
Does trauma risk management reduce psychological distress in deployed troops? Frappell-Cooke et. al. 2010	Occupational Medicine	Not mentioned / 2007-2008	A non-randomized parallel-group comparison within two groups of personnel: a company of army infantry (Coldstream Guards) (n= 586) Royal Marine Commandos (n= 594).	The initial sample sizes of 94 and 86. At follow-up, during and post-deployment, some 56 and 91 Royal Marines and 49 and 46 Coldstream Guards responded, respectively.

Occupational health needs of commercial fishermen in South West England. Grimsmo-Powney et. al. 2010	Occupational Medicine	Not mentioned	Survey of a convenience sample	210 (68%) of 307 fishermen approached three major fishing ports in South West England
Obesity and sickness absence: results from the CHAP study. Harvey et. al. 2010	Occupational Medicine	Not mentioned /2005-2007	Cross-sectional and prospective analyses	Cross-sectiona-1489 prospective-625 staff from London Underground Ltd. had BMI results calculated and stored.
A new approach to evaluating the well-being of police. Juniper et. al.	Occupational Medicine	Not mentioned	Cross-sectional	822 police force workers outside the metropolitan area of London.
Suicides among seafarers in UK merchant shipping, 1919–2005. Roberts et. al. 2010	Occupational Medicine	Not mentioned /1919-2005.	Examination of seafarers' death inquiry files, death registers and death returns; literature reviews and national suicide statistics.	Diseased cases of seafarers
Test–retest reliability of the Military Pre-training Questionnaire. Robinson et. al. 2010	Occupational Medicine	Not mentioned	Survey questionnaire	Fifty-eight male British Army infantry trainees
Hearing symptoms and audiometry in professional divers and offshore workers. Ross et. al. 2010	Occupational Medicine	Not mentioned	Cross-sectional design and screening audiometry.	151 divers and 120 offshore workers were randomly selected from groups of 1035 offshore workers and 1540 professional divers who had previously completed a health questionnaire study.
The predictive capacity of declared musculoskeletal disorder at pre-employment screening. Ryan, 2010	Occupational Medicine	Not mentioned /1993-2002	Retrospective cohort	594 individuals who joined as airport security staff
Musculoskeletal symptoms in pharmaceutical sales representatives Sang et. al. 2010	Occupational Medicine	2008	Cross-sectional questionnaire and interviews with 12 key personnel	205 pharmaceutical sales representatives

Medically reported work-related ill-health in the UK agricultural sector. Stocks et. al. 2010	Occupational Medicine	Not mentioned / 2002–2008	Analysis of data reported THOR	471 cases of WRI within the agricultural sector were reported to THOR (2% of all cases).
Mental health among commando, airborne and other UK infantry personnel. Sundin et. al. 2010	Occupational Medicine	Not mentioned /2003	Cross- sectional data from a prospective TELIC 1 cohort study	275, 202, 572 military groups who were in service during March 2003 and who participated in the first wave of a prospective cohort study
Compassion fatigue: experiences in occupational health, human resources, counselling and police Tehrani, 2010	Occupational Medicine	Not mentioned	Survey questionnaire	276 professionals from four caring professions.
The work environment, stress and well-being. Wadsworth et. al. 2010	Occupational Medicine	Not mentioned	Analytical study using the combined datasets of the Bristol and Cardiff Community Studies	8755 worker from electoral register
Health of national service veterans: an analysis of a community-based sample using data from the 2007 Adult Psychiatric Morbidity Survey of England. Woodhead et. al. 2010	Social Psychiatry and Psychiatric Epidemiology	Not mentioned /2007	Analyses were carried out using data collected for the Adult Psychiatric Morbidity Survey (APMS)	From the original study sample (N = 7461), 484 veterans and 301 non-veterans
Asbestosis and mesothelioma among British asbestos workers (1971–2005). Harding and Darnton, 2010	American Journal of Industrial Medicine	Not mentioned /1971-2005	Data analysis from The GB Asbestos Survey	99680 asbestos workers, overall there were 15557 deaths from all causes in the cohort.

Appendix B-4: the qualitative study interview schedule

The following are the main interview questions. More possible questions may arise during each interview, according to the participants' responses and the initial analysis of the earlier interviews.

1. Please tell me about yourself and your involvement and responsibilities in occupational epidemiology research? How long you have been involved in this field?
2. Can you think of a research project you were involved in that was easy to set up and get going, and tell me what helped it go well?
3. Can you think of another research project that was rather hard to set up and get going, and tell me why it did not go well?
4. Are the issues you have mentioned applicable to other research projects you have been involved in?

Probes:

- Have you experienced any difficulties in relation to ethical and governance issues? If yes, tell me more about these difficulties?
 - What do you think of the availability and the quality of information collected from record/registries/databases for research purposes?
 - Have you experienced any difficulties in publishing research results? If yes, why?
5. Do you think other researchers have experienced the same issues? Can you give me some examples? (Explore the differences and the similarities)
 6. How did you overcome the difficulties in setting up and running your research projects?
 7. How other researchers overcome such difficulties?
 8. What happened/have you done to your research projects because of these issues (either negative or positive)?

Probes:

- Have any of your studies been compromised or abandoned as a result of the difficulties you have experienced? If yes, can you give me some examples?
9. What impact these issues have on studies for other researchers?
 10. Have you or other researchers ever addressed the issues you have experienced within your publications? If yes, tell me more about it? If no, why?
 11. Do you have any suggestions that may help current or future research projects get set up and going well and as planned?
 12. Do you have any suggestions for how the difficulties might be addressed within current and future research projects?
 13. Do you recommend any other participants, whom you think may be useful to contact, for the purpose of this study?
 14. Do you know of any materials or references (either published or unpublished) that could be useful for me?
 15. Do you have any concerns or experiences regarding this topic that I haven't addressed during our conversation?

Appendix B-5: The study questionnaire

Research Challenges

a) We would like to know the extent to which you think each of the following situations is a challenge in carrying out occupational epidemiology research in the UK.

For each item, please circle the response that best represents your view, where 1= strongly agree, 2= agree, 3= neither agree nor disagree, 4=disagree, and 5=strongly disagree. If you change your mind, please cross out the original response, and circle the correct one.

The challenge statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. There are not sufficient funding bodies/ opportunities for research in this field	1	2	3	4	5
2. Online forms for grant applications are inappropriately designed for this type of research, which makes them difficult to complete	1	2	3	4	5
3. Industry/employer do not cooperate or refuse access to data/participants (e.g. due to fear of litigation or prosecution)	1	2	3	4	5
4. Agreement by industry/employer to access data/participants takes a long time, which delays the study	1	2	3	4	5
5. Permission from occupational physician or GP to access participants' records is difficult to obtain	1	2	3	4	5
6. NHS governance body approval to enable access to population/data is difficult to obtain	1	2	3	4	5
7. It is difficult to carry out some studies (e.g. cohort studies) because of the requirement of the ethics committees for explicit informed consent	1	2	3	4	5
8. The inconsistent interpretation of the ethical and governance frameworks (e.g. NHS Act (2006), DPA (1998)), by ethical and governance authorities, is causing difficulty in carrying out some research studies and following up some other ongoing studies	1	2	3	4	5
9. There are many inappropriately designed forms required to complete for ethical and governance applications, thus delaying the application process	1	2	3	4	5
10. Multi-centered studies are harder to set up, because of the unstandardised and the multiple approvals required by the governance bodies across centres.	1	2	3	4	5
11. It is difficult to get expert opinion on certain areas of occupational epidemiology, because there are few academic experts left in the UK	1	2	3	4	5

12. Records of the workforce are not arranged in an accessible manner to facilitate research	1	2	3	4	5
13. Early destruction of records for workers/employees is a major hurdle for conducting research studies	1	2	3	4	5
14. It is difficult to carry out some research studies due to the inaccuracy and incompleteness of the workers'/employees' records	1	2	3	4	5
15. A low response/participation rate is a major difficulty facing researchers in many studies	1	2	3	4	5
16. When a study's findings are made available to the workforce in the first instance, it is then harder to get them published in a scientific journal	1	2	3	4	5
17. It is difficult to convince industry to agree to publish negative study findings	1	2	3	4	5

Please state any other issues, not mentioned above, you think are challenges to occupational epidemiology research.

b) Which challenges from the above do you consider are the most important, and why?

c) What strategies have you employed to overcome the challenges you have experienced (e.g. Changing the study design, appeal against study disapproval)?

d) Why you have used these strategies?

e) Were these strategies successful?

Facilitators

f) We would like to know the extent to which you think each of the following situations is a facilitator to occupational epidemiology research in the UK?

For each item, circle the response that best represents your view, where 1= strongly agree, 2= agree, 3= neither agree nor disagree, 4=disagree, and 5=strongly disagree. If you change your mind, please cross out the original response, and circle the correct one.

The facilitator statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. Support from trade unions/work representatives facilitates the conduct of research studies	1	2	3	4	5
2. The role of the media is important in applying pressure on industry/employers for a particular disease/problem to be investigated	1	2	3	4	5
3. The media can help to advertise a particular study, and thus improve the study response/participation rate	1	2	3	4	5
4. Government interest and pressure for a particular disease/problem to be investigated facilitate the conduct of such studies	1	2	3	4	5
5. Pre-study formal and informal negotiations and discussions with relevant stakeholders to obtain approval is important	1	2	3	4	5
6. Keeping stakeholders involved by communicating with them about the study and following up unresolved issues	1	2	3	4	5
7. Studies carried out by or on behalf of the relevant regulatory bodies (e.g. Health and Safety Executive “HSE”) are easier to get approvals and cooperation from the relevant stakeholders	1	2	3	4	5
8. Studies that have been designed to specific gaps in government or other policies are easier to get approvals and cooperation from the relevant stakeholders	1	2	3	4	5
9. Data from previous large and well-designed epidemiological studies can be exploited to facilitate current studies	1	2	3	4	5

Please state any other things, not mentioned above, you think are facilitators to occupational epidemiology research in the UK.

g) Which facilitators from the above do you consider are the most important, and why?

h) Have you ever prematurely stopped any of your studies? If yes, why?

i) Have any of your studies been compromised? If yes, why?

j) Have any of your studies been considerably delayed? If yes, why?

k) Have you ever been unable to publish your research findings? If yes, why?

Demographic and background information

1. What is your highest level of education?

Undergraduate degree

Master's degree

Doctorate

Other (please indicate)

2. What is your primary work area in occupational epidemiology research?

.....

3. Please choose one that best suits your current role?

Physician

Nurse

Statistician

Epidemiologist

Occupational Hygienist

Other, (please specify)

4. Who is your employer?

University

Governmental body

Research institute/charity

Industry

National Health Service (NHS)

Other, (please specify)

5. For how many years you have been involved in occupational epidemiology research?

.....

6. Please list any other researchers or stakeholders you think they might be interested in completing the questionnaire.

Appendix B-6: Research Challenges results

The challenge statement	Strongly agree/Agree % (number)	Neither agree nor disagree% (number)	Strongly disagree/Disagree % (number)
1. There are not sufficient funding bodies/ opportunities for research in this field	73.1(38)	17.3(9)	9.4 (5)
2. Online forms for grant applications are inappropriately designed for this type of research, which makes them difficult to complete	28.8 (15)	56.6 (30)	13.2 (7)
3. Industry/employer do not cooperate or refuse access to data/participants (e.g. due to fear of litigation or prosecution)	38.5 (20)	41.5 (22)	18.9 (10)
4. Agreement by industry/employer to access data/participants takes a long time, which delays the study	67.3 (35)	26.4 (14)	5.7 (3)
5. Permission from occupational physician or GP to access participants' records is difficult to obtain	69.6 (31)	32.1 (17)	7.5 (4)
6. NHS governance body approval to enable access to population/data is difficult to obtain	57.7 (30)	28.3 (15)	13.2 (7)
7. It is difficult to carry out some studies (e.g. cohort studies) because of the requirement of the ethics committees for explicit informed consent	67.3 (35)	15.1 (8)	27 (8)
8. The inconsistent interpretation of the ethical and governance frameworks (e.g. NHS Act (2006), DPA (1998)), by ethical and governance authorities, is causing difficulty in carrying out some research studies and following up some other ongoing studies	57.7 (30)	35.8 (19)	5.7 (3)
9. There are many inappropriately designed forms required to complete for ethical and governance applications, thus delaying the application process	57.7 (30)	30.2 (16)	11.3 (6)
10. Multi-centered studies are harder to set up, because of the unstandardised and the multiple approvals required by the governance bodies across centres.	65.4 (34)	26.4 (14)	7.5 (4)
11. It is difficult to get expert opinion on certain areas of occupational	46.2 (24)	26.4 (14)	26.4 (14)

epidemiology , because there are few academic experts left in the UK			
12. Records of the workforce are not arranged in an accessible manner to facilitate research	82.7 (43)	17.3 (9)	0
13. Early destruction of records for workers/employees is a major hurdle for conducting research studies	42.3 (22)	47.2 (25)	9.4 (5)
14. It is difficult to carry out some research studies due to the inaccuracy and incompleteness of the workers'/employees' records	67.9 (36)	30.2 (16)	1.9 (1)
15. A low response/participation rate is a major difficulty facing researchers in many studies	86.8 (46)	5.7 (3)	7.5 (4)
16. When a study's findings are made available to the workforce in the first instance, it is then harder to get them published in a scientific journal	3.8 (2)	49.1 (26)	45.2 (24)
17. It is difficult to convince industry to agree to publish negative study findings	25 (13)	47.2 (25)	26.4 (14)

Appendix B-7: Research facilitators results

The facilitator statement	Strongly agree/Agree% (number)	Neither agree nor disagree%(number)	Strongly disagree/Disagree% (number)
1. Support from trade unions/work representatives facilitates the conduct of research studies	80.8 (42)	15.1 (8)	3.8 (2)
2. The role of the media is important in applying pressure on industry/employers for a particular disease/problem to be investigated	59.6 (31)	32.1 (17)	7.5 (4)
3. The media can help to advertise a particular study, and thus improve the study response/participation rate	57.7 (30)	32.1 (17)	9.4 (5)
4. Government interest and pressure for a particular disease/problem to be investigated facilitate the conduct of such studies	92.3 (48)	5.7 (3)	1.9 (1)
5. Pre-study formal and informal negotiations and discussions with relevant stakeholders to obtain approval is important	88.5 (46)	11.3 (6)	0
6. Keeping stakeholders involved by communicating with them about the study and following up unresolved issues	84.6 (44)	13.2 (7)	1.9 (1)
7. Studies carried out by or on behalf of the relevant regulatory bodies (e.g. Health and Safety Executive “HSE”) are easier to get approvals and cooperation from the relevant stakeholders	51.9 (27)	39.6 (21)	7.5 (4)
8. Studies that have been designed to specific gaps in government or other policies are easier to get approvals and cooperation from the relevant stakeholders	67.3 (35)	32.1 (17)	0
9. Data from previous large and well-designed epidemiological studies can be exploited to facilitate current studies	81.1 (43)	17 (9)	1.9 (1)

Appendix C-1: bibliometric study search strategy

S44	s42 not s43	Search modes - Boolean/Phrase	Results (14,140)
S43	(MM "Prognosis+")	Search modes - Boolean/Phrase	Results (26,993)
S42	s40 not s41	Search modes - Boolean/Phrase	Results (14,247)
S41	(MM "Evaluation Studies as Topic+")	Search modes - Boolean/Phrase	Results (75,375)
S40	s38 not s39	Search modes - Boolean/Phrase	Results (14,314)
S39	(MM "Education+")	Search modes - Boolean/Phrase	Results (370,721)
S38	s36 not s37	Search modes - Boolean/Phrase	Results (14,543)
S37	(MH "Therapeutics+")	Search modes - Boolean/Phrase	Results (3,102,882)
S36	s34 not s35	Search modes - Boolean/Phrase	Results (18,527)
S35	(MM "Antineoplastic Agents+")	Search modes - Boolean/Phrase	Results (186,862)
S34	s32 not s33	Search modes - Boolean/Phrase	Results (18,765)
S33	(MH "Neoplasm Metastasis+")	Search modes - Boolean/Phrase	Results (144,773)
S32	s30 not s31	Search modes - Boolean/Phrase	Results (20,039)
S31	(MM "Neoplasm Metastasis")	Search modes - Boolean/Phrase	Results (14,804)
S30	s28 not s29	Search modes - Boolean/Phrase	Results (20,080)
S29	(MH "Meta-Analysis as Topic") OR (MM "Meta-Analysis")	Search modes - Boolean/Phrase	Results (12,360)
S28	s26 not s27	Search modes - Boolean/Phrase	Results (20,121)
S27	(MM "Questionnaires")	Search modes - Boolean/Phrase	Results (25,682)
S26	s24 not s25	Search modes - Boolean/Phrase	Results (20,227)
S25	(MM "Clinical Trials as Topic")	Search modes - Boolean/Phrase	Results (21,506)
S24	s22 not s23	Search modes - Boolean/Phrase	Results (20,301)
S23	(MM "Palliative Care")	Search modes - Boolean/Phrase	Results (19,344)

S22	s20 not s21	Search modes - Boolean/Phrase	Results (20,545)
S21	(MM "Mass Screening")	Search modes - Boolean/Phrase	Results (39,136)
S20	s18 not s19	Limiters - Date of Publication from: 19600101-20121231; English Language Search modes - Boolean/Phrase	Results (21,528)
S19	(MM "Antineoplastic Combined Chemotherapy Protocols") OR (MM "Induction Chemotherapy") OR (MM "Maintenance Chemotherapy") OR (MM "Chemotherapy, Adjuvant") OR (MM "Antineoplastic Agents") OR (MM "Drug Therapy, Combination")	Search modes - Boolean/Phrase	Results (187,306)
S18	S6 not s17	Search modes - Boolean/Phrase	Results (22,816)
S17	S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16	Search modes - Boolean/Phrase	Results (14,097)
S16	S1 AND S2 AND S5	Limiters - Publication Type: Validation Studies Search modes - Boolean/Phrase	Results (274)
S15	S1 AND S2 AND S5	Limiters - Publication Type: Review Search modes - Boolean/Phrase	Results (5,817)
S14	S1 AND S2 AND S5	Limiters - Publication Type: News, Newspaper Article, Overall, Patient Education Handout, Periodical Index, Practice Guideline, Published Erratum, Randomized Controlled Trial Search modes - Boolean/Phrase	Results (2,148)
S13	S1 AND S2 AND S5	Limiters - Publication Type: Lectures, Legal Cases, Legislation, Letter, Meta-Analysis Search modes - Boolean/Phrase	Results (1,399)
S12	S1 AND S2 AND S5	Limiters - Publication Type: Guideline, Historical Article, In Vitro, Interactive Tutorial, Interview, Introductory Journal Article Search modes - Boolean/Phrase	Results (202)
S11	S1 AND S2 AND S5	Limiters - Publication Type: Evaluation Studies, Festschrift Search modes - Boolean/Phrase	Results (1,008)
S10	S1 AND S2 AND S5	Limiters - Publication Type: Congresses, Consensus Development Conference, Consensus Development	Results (624)

		Conference, NIH, Controlled Clinical Trial, Dictionary, Directory, Duplicate Publication, Editorial Search modes - Boolean/Phrase	
S9	S1 AND S2 AND S5	Limiters - Publication Type: Clinical Conference, Clinical Trial, Clinical Trial, Phase I, Clinical Trial, Phase II, Clinical Trial, Phase III, Clinical Trial, Phase IV, Comment Search modes - Boolean/Phrase	Results (3,522)
S8	S1 AND S2 AND S5	Limiters - Publication Type: Addresses, Autobiography, Bibliography, Biography, Case Reports Search modes - Boolean/Phrase	Results (2,148)
S7	S1 AND S2 AND S5	Limiters - EBM Reviews Search modes - Boolean/Phrase	Results (217)
S6	S1 AND S2 AND S5	Search modes - Boolean/Phrase	Results (36,913)
S5	S3 OR S4	Search modes - Boolean/Phrase	Results (1,099,338)
S4	AB (UK OR "United Kingdom" OR U.K OR Britain OR England OR Wales OR Scotland OR Ireland) OR AF (UK OR "United Kingdom" OR U.K OR Britain OR England OR Wales OR Scotland OR Ireland) OR CA (UK OR "United Kingdom" OR U.K OR Britain OR England OR Wales OR Scotland OR Ireland) OR TI (UK OR "United Kingdom" OR U.K OR Britain OR England OR Wales OR Scotland OR Ireland)	Search modes - Boolean/Phrase	Results (922,610)
S3	(MH "Great Britain+")	Search modes - Boolean/Phrase	Results (281,299)
S2	(MM "Neoplasms+")	Search modes - Boolean/Phrase	Results (2,068,494)
S1	(MH "Epidemiology+") OR (MH "Epidemiologic Factors+") OR (MH "Epidemiologic Methods+") OR (MH "Epidemiologic Studies+") OR (MH "Epidemiologic Measurements+")	Search modes - Boolean/Phrase	Results (4,379,061)

Appendix D-1: MRC, HSC, and CRC annual reports reviewed in the documentary study

Medical Research Council annual reports

Medical Research Council Annual Report, April 1979-March 1980. London: HMSO, 1980.
Medical Research Council Annual Report, April 1980-March 1981. London: HMSO, 1981
Medical Research Council Annual Report, April 1981-March 1982. London: HMSO, 1982
Medical Research Council Annual Report, April 1982-March 1983. London: HMSO, 1983.
Medical Research Council. Annual Report: April 1983-March 1984. London: HMSO, 1984.
Medical Research Council. Annual Report: April 1984-March 1985. London: HMSO, 1985.
Medical Research Council. Annual Report: April 1985-March 1986. London: HMSO, 1986.
Medical Research Council. Annual Report: April 1986-March 1987. London: HMSO, 1987.
Medical Research Council. Annual Report: April 1987-March 1988. London: HMSO, 1988.
Medical Research Council. Annual Report: April 1988-March 1989. London: HMSO, 1989.
Medical Research Council. Annual Report: April 1989-March 1990. London: HMSO, 1990.
Medical Research Council. Annual Report: April 1990-March 1991. London: HMSO, 1991.
Medical Research Council. Annual Report: April 1991-March 1992. London: HMSO, 1992.
Medical Research Council. Annual Report: April 1992-March 1993. London: HMSO, 1993.
Medical Research Council. Annual Report: April 1993-March 1994. London: HMSO, 1994.
Medical Research Council. Annual Report: April 1994-March 1995. London: HMSO, 1995.
Medical Research Council. Annual Report: April 1995-March 1996. London: HMSO, 1996.

Health and Safety Commission annual reports

Health and Safety Commission. Annual Report 1980/81: Health and Safety Commission. London: H.M.S.O., 1981.
Health and Safety Commission. Annual Report 1981/82: Health and Safety Commission. London: H.M.S.O., 1982.
Health and Safety Commission. Annual Report 1982/83: Health and Safety Commission. London: H.M.S.O., 1983.
Health and Safety Commission. Annual Report 1983/84: Health and Safety Commission. London: H.M.S.O., 1984.
Health and Safety Commission. Annual Report 1984/85: Health and Safety Commission. London: H.M.S.O., 1985.
Health and Safety Commission. Annual Report 1985/86: Health and Safety Commission. London: H.M.S.O., 1986.
Health and Safety Commission. Annual Report 1986/87: Health and Safety Commission. London: H.M.S.O., 1987.
Health and Safety Commission. Annual Report 1987/88: Health and Safety Commission. London: H.M.S.O., 1988.
Health and Safety Commission. Annual Report 1988/89: Health and Safety Commission. London: H.M.S.O., 1989.
Health and Safety Commission. Annual Report 1989/90: Health and Safety Commission. London: H.M.S.O., 1990.
Health and Safety Commission. Annual Report 1990/91: Health and Safety Commission. London: H.M.S.O., 1991.
Health and Safety Commission. Annual Report 1991/92: Health and Safety Commission. London: H.M.S.O., 1992.
Health and Safety Commission. Annual Report 1992/93: Health and Safety Commission. London: H.M.S.O., 1993.
Health and Safety Commission. Annual Report 1993/94: Health and Safety Commission. London: H.M.S.O., 1994.
Health and Safety Commission. Annual Report 1994/95: Health and Safety Commission. London: H.M.S.O., 1995.
Health and Safety Commission. Annual Report 1995/96: Health and Safety Commission. London: H.M.S.O., 1996.

Cancer Research Campaign annual reports

Cancer Research Campaign. Annual Report 1980. Great Britain: Cancer Research Campaign, 1981.

Cancer Research Campaign. Annual Report 1981. Great Britain: Cancer Research Campaign, 1982.
Cancer Research Campaign. Annual Report 1982. Great Britain: Cancer Research Campaign, 1983.
Cancer Research Campaign. Annual Report 1983. Great Britain: Cancer Research Campaign, 1984.
Cancer Research Campaign. Annual Report 1984. Great Britain: Cancer Research Campaign, 1985.
Cancer Research Campaign. Annual Report 1985. Great Britain: Cancer Research Campaign, 1986.
Cancer Research Campaign. Annual Report 1986. Great Britain: Cancer Research Campaign, 1987.
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Cancer Research Campaign. Annual Report 1988-89. Great Britain: Cancer Research Campaign, 1989.
Cancer Research Campaign. Annual Report 1989-90. Great Britain: Cancer Research Campaign, 1990.
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Cancer Research Campaign. Annual Report 1991-92. Great Britain: Cancer Research Campaign, 1992.
Cancer Research Campaign. Annual Report 1992-93. Great Britain: Cancer Research Campaign, 1993.
Cancer Research Campaign. Annual Report 1993-94. Great Britain: Cancer Research Campaign, 1994.
Cancer Research Campaign. Annual Report 1994-95. Great Britain: Cancer Research Campaign, 1995.
Cancer Research Campaign. Annual Report 1995-96. Great Britain: Cancer Research Campaign, 1996

Appendix D-2: Analytical Framework for the documentary analysis

<u>Initial categories and related questions</u>	<u>Example of codes</u>	<u>Final themes adopted</u>
<p>Key researchers influence</p> <ol style="list-style-type: none"> <i>The role and influence of key leaders' scientific, political and personal backgrounds on funding</i> <i>Is funding continued to be allocated to certain researcher and on what basis?</i> <i>Is there evidence that key funding bodies' leaders (if researchers) are supported? What is their role in supporting certain programmes?</i> 	<ul style="list-style-type: none"> • New Chairman/leader • New Department/group leader or director • Responses to key researchers appointments • Awards to key members and grantee • Support to key leaders/researchers • Nobel Prize effect 	<p>(1) The influence of key leaders and/or researchers in positions of power or leadership</p>
<p>Policy issues</p> <ol style="list-style-type: none"> <i>What internal and external policies influenced funding decisions and allocations and why?</i> <i>Who created these policies and why?</i> <i>What are the effects of EU and international policies on funding certain areas?</i> 	<ul style="list-style-type: none"> • Universities funding issues • New corporate plan • Department of Health related • Governmental policies • New funding policies • International related • EU related • Due to public and media influence • Criteria for funding 	<p>(2) The influence of internal and external policies</p>
<p>Collaboration</p> <p><i>Is there evidence of encouraging collaborative studies and why?</i></p>	<ul style="list-style-type: none"> • Universities collaboration • National collaboration • International collaboration • Industry collaboration • Collaboration influence • Encouraging multidisciplinary • Relevant policies/initiatives 	<p>(3) Collaboration</p>
<p>Technological and scientific development</p> <ol style="list-style-type: none"> <i>The effect of these on funding decisions and allocations and on the perceptions of funders.</i> <i>Was there any evidence that these changed the type of work and workplace environment?</i> <i>What are the perception of funders in relation to past and new exposures and funding issues?</i> 	<ul style="list-style-type: none"> • Support for new technology • New work exposures due to technologies • Biotechnology evolution • New development due to technologies 	<p>(4) Technological development and evolution of new methods and techniques</p>

<p>New methods-molecular and genetic techniques</p> <ol style="list-style-type: none"> <i>The perceptions of these and the influence in funding</i> <i>Evidence of supporting (or not) studies of this type and why</i> 	<ul style="list-style-type: none"> New development Facilitating genetic and molecular work Britain's role/image Commercial exploitation 	<p>(5) Technological development and evolution of new methods and techniques</p>
<p>Financial issues</p> <ol style="list-style-type: none"> <i>Funding allocations issues and income of funding bodies and the effect on prioritising and funding projects.</i> <i>Why certain groups/departments/units were established or supported?</i> <i>Who decided to support them?</i> <i>What is the effect of the level of income on funding priorities?</i> 	<ul style="list-style-type: none"> Successful units after review New Unit/ departments /group New funding arrangements Funding priorities Financial difficulty/recession Closure of units/departments Financial improvement 	<p>This category was relevant to different themes, but mainly to 1, 2, and 3.</p> <p>It also facilitated quantitative part of the analysis.</p>
<p>Epidemiology\Occupational Epidemiology</p> <p><i>Specifically looking for OE and PHE studies that were mentioned to be funded and why</i></p>	<ul style="list-style-type: none"> Funded OE projects/programmes Funded PHE projects/programmes Funded RCTs 	<p>Funding issues related to epidemiological studies</p>
<p>Career structure</p> <p><i>How career structure being mapped/influenced for scientist and researchers in each funding body and on what basis</i></p>	<ul style="list-style-type: none"> Fellowships issues Studentships Incentives 	<p>This category linked to different themes</p>
<p>Funding bodies' characteristics</p> <ul style="list-style-type: none"> <i>What are the characteristics of each funding body?</i> <i>What are the aims and funding strategies?</i> <i>To capture any new changes, and why?</i> 	<ul style="list-style-type: none"> MRC CRC HSE Changes in the annual reports 	<p>This category facilitated the descriptions of each funding body's characteristics</p>
<p>Other issues</p> <p><i>Issues not covered by the analytical framework</i></p>		<p>No new issues identified</p>

Appendix D-3: MRC funded fields

Total- Environment	Environment: sound and vibration
	Environment: radiation
	Environment: other physical agents (heat, cold, pressure etc.)
	Environment: psychological and physiological factors affecting performance
	Environment: accidents, including burns and trauma
	Environment: general factors affecting health
	Environment: chemical and physical hazards
	Nutrition
Total- Infections	Tropical medicine
	Protozoal infection
	Helminth infection
	Other parasitic infection
	Other tropical infection
	Infections
Total- cancer	Cancer: carcinogenesis
	Cancer: incident/epidemiology/detection
	Cancer: tumour biology
	Cancer: therapy
Total- Molecular	Molecular structure
	Metabolism
	cell and tissue
	Immune system
Total – Central Nervous System (CNS)	Vision

	Hearing
	CNS
	Neuromuscular
	Cerebrovascular
	Other sensory system
	Pain
Total -body systems	Blood
	Cardiovascular system
	Respiratory system
	Gastrointestinal tract
	Kidneys and urinary tract
	Teeth and associated tissues
	Muscle, bone and joints
	Endocrine glands
	Skin
Total -psychosocial	Behaviour/psychology/cognitive processes
	Mental handicap
	Psychiatric disorders
	Addiction (including smoking and alcoholism)
Total- human development	Inheritance
	Fertility/contraceptive/abortion
	Pregnancy and foetal development
	Postnatal development
	Aging
Total -others	Organisation of medical care
	Services and techniques

Appendix D-4: Projects list of epidemiological studies funded by CRC 1980-1990

Project name	Year	Place	PI	Type	Topic
Coding backlog of registry's data expedite clinical and epidemiological analytical research	1982	Birmingham Queen Elizabeth Hospital	J Powell	General	Database
Cancer Epidemiology Group	1979-85	Birmingham University, Department of Social Medicine	J A H Waterhouse (Head)	General	Not clear
Regional case-control studies of the aetiology of childhood cancer	1980-86	Birmingham University, Department of Social Medicine (later in 1985 called cancer epidemiology unit)	J A H Waterhouse	PHE	Childhood cancer
Epidemiology and biostatistics in cancer research	1977-83	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital	J Chamberlain	General	Not clear
Early detection of large-bowel cancer in a working population	1981	London Hospital Medical college	A J Silman and R J Nichols	OE	Bowel cancer
Bladder cancer in the printing industry: an historical prospective mortality study of printing industry	1980-81	LSHT	V Beral	OE	Bladder cancer
Analysis of cancer statistics in OPCS longitudinal study	1981-83	LSHT	A M Adelstein	PHE	Incidence
Epidemiological work on the role of immune, dietary and occupational factors in cancer aetiology	1980-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	Both	Nutrition and occupation

Study of the incidence of malignant disease in patient who have received treatment with immunosuppressive drugs	1969-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen and R Doll	Clinical epidemiology	Patient received immunosuppressive drugs
A study of cancer incidence and mortality in renal dialysis patients	1976-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	Clinical epidemiology	Renal dialysis patients
A study of cancer incidence and mortality in patients with immune deficiencies disorders	1976-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	Clinical epidemiology	Patient with immune deficiencies disorders
Register of women who have received oestrogens in pregnancy	1976-81	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen, M P Vessey and MRC	PHE	Registry of women received oestrogen
A study of mortality of asbestos workers with particular reference to mesothelioma and lung cancer	1976-81	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen, J Peto and R Doll	OE	Asbestos lung diseases
A study of occupational factors in Leukaemia	1975-83	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	OE	Leukaemia
A study of mortality in meat-abstaining religious orders	1977-83	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Nutrition
A mortality study of immigrants from India and Pakistan	1977-83	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen and OPCS	PHE	Hereditary
A study of cancer mortality in mothers of babies with anencephaly	1976-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Hereditary
Mortality study of individuals covered by dietary studies in the past	1978-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Nutrition

A case-control study of cancer in immigrants from India and Pakistan	1979-83	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Nutrition
A follow-up study of hyperimmunised individuals	1979-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Immunisation
A case-control study of non-Hodgkin's lymphoma	1979-81	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	lymphoma
Studies of Vitamin A and Cancer	1979-87	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Nutrition
A study of cancer in family members of patients with Fanconi's anaemia, Ataxia telangiectasia, breast and colon cancer	1979-83	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Hereditary
Cancer and other diseases in vegetarians	1980-87	Oxford Radcliffe Infirmary (department of community medicine and general practice, Head MP Vessey)	J I Mann	PHE	Nutrition
Further studies of cancer in Buckinghamshire furniture workers	1981	MRC environmental epidemiology unit (University of Southampton)	E D Acheson (head of dep)	OE	Furniture workers
CRC cancer epidemiology unit	1983	University of Edinburgh, Faculty of Medicine	L J Kinlen	General	Not clear
Diet and colon cancer in Asian immigrants	1982	LSHT	A M Adelstein and M G Marmot	PHE	Nutrition
Cancer Epidemiology	1980	University hospital of South Manchester, Department of epidemiology and social research (A Smith head)	A Smith	PHE	Not clear

Study of T-cell leukaemia lymphoma in Caribbean people	1982	Oxford, Radcliffe Infirmary	L J Kinlen	PHE	Leukaemia
Review of cancer mortality and incidence in Scotland	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Incidence & mortality
A study of increased cancer risk among family members of individuals with different forms of cancer	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Hereditary
A case-control study of fertility among young married women with breast cancer	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Breast cancer
A study of cancer incidence among individuals exposed to in utero irradiation	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Irradiation
A prospective study of cancer among individuals covered by pre-war dietary surveys by the Rowett Institute, Aberdeen	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	PHE	Nutrition
A prospective study of leukaemia and other malignancies in benzene workers	1983-90	Oxford, Radcliffe Infirmary (CRC cancer epidemiology research group)	L J Kinlen	OE	Leukaemia and other cancers
Studies on genetic pre-disposition to cancer	1984-90	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	J Peto (D Easton, and K Anderson 1990)	PHE	genetics
Case-control studies involving the possible effect of oral contraceptives on breast cancer incidence	1984-86	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	J Peto	PHE	Oral contraceptive /breast cancer
Studies on various industrial exposure including nickel and asbestos	1984-90	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	J Peto, D Easton (1987)	OE	Nickel and asbestos

Collaborative clinical research with local clinicians and other clinical trial groups	1984-86	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	J Peto	General	Not clear
Prevention of cancer mortality	1984-87	London, St Bartholomew's Hospital Medical College, Environmental and preventative medicine	H S Cuckle	PHE	Not clear
The Manchester Children's Tumour Registry: Studies on incidence, survival and aetiology of paediatric neoplasms in North-West England	1984-87	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Childhood cancer
Patterns of malignant disease among the families of children with bone and soft-tissue sarcomas and adrenal cortical tumours	1984-87	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Childhood cancer
A case-control study of sarcomas and adrenal cortical tumours in children and young adults in North-West England	1984-87	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Childhood cancer
A study of the morphology of breast cancer in relation to family history of breast and other cancers	1984-87	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Hereditary
Study of secular and spatial variations in the incidence and prognosis of cancer in the north-western region	1984-86	University Hospital of South Manchester, Department of Epidemiology and social research	A Smith	PHE	Incidence
The epidemiology of lymphoid neoplasms in the north-west of England	1984	University Hospital of South Manchester, Department of Epidemiology and social research	A Smith	PHE	Incidence and mortality
United Kingdom Children's Cancer Study Group administrative and trials office	1983-87	University Hospital of South Manchester, Department of Epidemiology and social research	S C Cartwright and J M Barnes	PHE	Childhood cancer

Epidemiology aspects of breast cancer-mode diagnosis and delay behaviour	1983-87	University of Nottingham, Department of community health and surgery	J M Elwood and R W Blamey	Clinical epidemiology	Breast cancer
Coarse fishing and risk of urothelial cancer: A case control study	1985	Birmingham University, Department of Social Medicine (later in 1985 called cancer epidemiology unit)	J A H Waterhouse/E G Knox	OE	Coarse fishing
Chemical associated renal pelvic and ureteral urothelial hyperplasia and carcinoma	1986-87	University of Surrey	P H Bach	OE	Chemicals
Survival of patients attending the Bristol Cancer Help Centre	1986	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	C E D Chilvers	Clinical epidemiology	Survival
Malignant melanoma and exposure to natural and artificial light	1986-87	University of Nottingham, Department of community health	J M Elwood	PHE	Artificial and natural light
Diet, faecal characteristics and colorectal adenomatous polyps: proposal for a case-control study	1986-87	University of Nottingham, Department of community health	J Little, R Logan, J D Hardcastle	PHE	Nutrition
Cancer Epidemiology Group	1979-85	Birmingham University, Department of Social Medicine (later in 1985 called cancer epidemiology unit)	E G Knox	General	Not clear
Case control studies on breast and testicular cancer	1987-90	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	C E D Chilvers and J Peto	PHE	Breast and testicular cancer
The cancer families group: Pedigree workers in Manchester	1987-90	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	General	Not clear
An investigation of the aetiology and natural history of cervical neoplasia	1989	Birmingham University, Department of Social Medicine	C B J Woodman and L Young	PHE	Aetiology
Epidemiological study of the incidence of cancer in Crohn's disease	1989	Birmingham University, Gastroenterology Unit	R N Allan	PHE	Incidence

Human papilloma viruses and cervical cancer	1990	Institute of cancer research (ICR jointly with MRC) Royal cancer Hospital, section of epidemiology	J Peto	PHE	Papilloma viruses
The leukaemogenicity of cytostatic drugs used in cancer therapy: case control studies to assess dose response relationships	1990	LSHT	P Fraser, and N Day	Clinical epidemiology	Leukemogenicity drugs
CRC atlas of cancer incidence in England and Wales	1990	LSHT	A J Swerdlow	PHE	Incidence
Cancer Screening	1990	London, St Bartholomew's Hospital Medical College, Environmental and preventative medicine	H S Cuckle and N Wald	Screening	Not clear
The aetiology and genetics of Wilms' tumour and childhood neural tumour	1990	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Childhood cancer
Studies of Li-Fraumeni syndrome	1990	University Hospital of South Manchester, Department of Epidemiology and social research	J M Birch	PHE	Not clear
Analysis of data from case control studies of the aetiology of testicular cancer and cryptorchidism	1990	University of Nottingham, Department of public health and epidemiology	C Chilvers	PHE	Aetiology
Diet and colorectal cancer: a case-control study	1990	University of Nottingham, Department of community health	J Little, R Logan, J D Hardcastle	PHE	Nutrition
Cancer and other diseases in vegetarians	1990	Oxford Radcliffe Infirmary (department of community medicine and general practice, Head MP Vessey)	M Thorogood and M P Vessey	PHE	Nutrition
Studies in genetic epidemiology of cancer	1990	University of Southampton, CRC genetic epidemiology research group	N E Morton	PHE	Genetics

Appendix D-5: Case Studies to illustrate the influence of key Leaders and researchers

The chairmen of the MRC

The chairman, secretary and the Council board members are appointed by the Secretary of State for Health. There were two chairmen for the MRC during the study period; Lord Earl Jellicoe (1981-1990) and Sir David Plastow (1990–1998).

Lord Earl Jellicoe (1981-1990)

Before and during his appointment as a Chairman of the MRC, Jellico had been the president of the Parliamentary and Scientific Committee, and Chairman of Tate & Lyle Plcl and a member of the Overseas Trade Board. Thus he was politician, diplomat and businessman. He has no scientific background, but his political and leadership experience was welcomed by the MRC when he was appointed:

“The Council are again fortunate in having a chairman with outstanding political and ministerial experience to guide them over the next four years” (MRC AR, 1980/81).

During his chairmanship, he was able to negotiate and successfully obtained ring-fenced funds (extra and regular funds without undertaking a peer review process) for two directed programmes (AIDS Directed Programme (ADP), and Human Genome Directed Programme (HGDP)) despite the difficult economic climate and cuts in research grant-in-aid. Although there were other factors that contributed to successfully securing funds to those programmes, Jellico’s political background and parliamentary presence had the most influence.

‘Lord Shepherd has been succeeded in the chairmanship by Lord Jellicoe, who has been President of the Parliamentary and Scientific Committee since 1980, and Chairman of the Council, King’s College London, since 1977. He is Chairman of Tate & Lyle Plc and a member of the Overseas Trade Board. The Council is again fortunate in having a chairman with outstanding political and ministerial experience to guide them over the next four years.’ (MRCAR, 1981/82)

His interest in this subject was also reflected by his direct support and management of the ADP through chairing the Council Committee on AIDS. In his retirement he was praised for his support for ADP and political influence:

“He (Jellico) was a skilled advocate for the Council, publicising and promoting the Council’s work in political and parliamentary circles. He will be remembered especially for his role in initiating the Council’s AIDS Programme, involving negotiations with Ministers about funding; and for his continuing interest in the development and implementation of that programme and its alignment with the needs of Government, the Department of Health and AIDS charities.” (MRC AR, 1990/91).

Sir David Plastow (1990–1998)

Plastow, as Jellico, had no scientific background, but had a distinguished career in motor industry and was a Chairman of Vickers plcl (British defence and motor company) during his chairmanship. He has no previous experience of medical research and his primary interest had been in profit generation. This was obvious in his first forward after he was appointed as the MRC Chairman in 1992:

“I became Chairman of the Medical Research Council two years ago and it was my first real immersion in the world of medical research. An “outsider’s” impression may be of general interest.

I have been very impressed by the calibre and commitment of the people with whom I am now working- whether member of the council itself or of its advisory boards and committees or researchers funded by MRC- and with the quality of their work. Moreover, as someone used to the disciplines imposed by the profit motive, I have been reassured by the extent to which value for money judgments are brought to bear at each stage of the council’s review and decision-making procedures.

Much medical research is of a long-term nature- an important reason for our investment in industries and units- and requires commitment and stability of funding. Coming from industry I am in no doubt that maintain and increasing investment in research is vital for the future of our country” (MRC AR, 1992-93).

This was written two years after his appointment. In the first year of Plastow’s appointment Rees presented the Chairman statement instead. This could be explained by Plastow’s lack of medical research experience, which could also explain his focus on his industrial background and profit generation issues rather than medical research, in his first forward statement (as above) in the second year of his appointment.

Rees was praised by Plastow at least twice in his MRC AR forward statements:

‘For me a highlight of the year has been to observe the powerful impact UK medical research has been making on the European scene, led by Sir Dai Rees — not only as President of the European Science Foundation, but also through his membership of a variety of European bodies. Sir Dai has taken UK medical research into the heart of Europe — to the benefit of the UK and of Europe as a whole. In this he has been ably supported by Dr David Evered, whose input to the EC’s BIOMED programme has been invaluable.’ MRC AR, 1994-95

And again in 1996:

‘This is the last of nine annual reports during Sir Dai Rees’ distinguished stewardship of the MRC first as secretary and then as chief executive. I want to mention in particular the role he played in the development of new scientific initiatives in genetics, neurosciences and health services research, in providing the impetus to the range of MRC activities in technology transfer, and in establishing a successful new style of relationship, enshrined in concordats, with the Health Departments, the Overseas Development Administration and other government departments. Dai has also made a major contribution to European science through his presidency of the European Science Foundation. On behalf of the MRC I would like to record our warm appreciation of his leadership through a time of major change in management of national and international science and to wish him well in the future.’ (MRC AR, 1995-96)

Parliamentary debate about Government Running Costs, Ian McCartney, a Labour Party Member of Parliament (MP) from 1987 to 2010, argued that:

'.....The Tories really investigated the credentials of people they put in charge of public funds. David Plastow ran the Medical Research Council for the simple reason that his company consistently donated to the Tory party.' (HC Deb 18 January 2000 vol 342 cc750-800).

Professor D G Harnden

In 1982 Professor D G Harnden was appointed to the director of Paterson laboratories after Lajtha retired in 1983. Immediately after his appointment and before he actually started his job, he attended a face to face meeting with the CRC Scientific Committee to discuss “problems and issues” as stated in the 1982 CRC annual report. There was no discussion in the report regarding what these problems were. Nonetheless, as a result of this meeting, the Scientific Committee agreed to establish a “a much-needed” new Division of Molecular Biology at the Paterson Laboratories, together with a small Cell Biology Group to accommodate Professor Harnden’s own research interests. However, *“in this instance a visit (by the Scientific Committee) was not required”*. Professor Harnden also became a member of the Scientific Committee in 1983.

It was obvious that there was an interest in Harnden’s area to an extent of supporting his plans for introducing molecular biology and cancer genetics in the laboratory and by his appointment as a member of the Scientific Committee.

'a new department of Cancer Genetics was set up under the Director of the Laboratories Professor D G Harnden. This reflects not only one of his special interests but also the current importance attached to this branch of cancer research.' (CRC AR, 1984).

An interview with Harnden was undertaken by Peter Harper in 2004 (published online) to document the history of Human Genetics. Harnden provided more background on his employment as the director of the Paterson laboratories, which reflected further the interest of the CRC in his work. At that time he was leading a small group of 5 scientists at The CRC Laboratories of the Department of Cancer Studies at the University of Birmingham:

'I had seen the advertisement for the job in Manchester (referring to the director of Paterson laboratories). I hadn't paid any attention and then I had a phone call from Alistair Currie, who was at that time Chairman of the CRC Scientific Committee, and he said "Are you interested" and I said "Maybe" and he said "Laddie. You will be 100 miles nearer to civilisation", and I guess that did it. 100 miles nearer to civilisation.' ('Genetics and Medicine Historical Network', n.d.)

Furthermore, in 1986, when the CRC established the Scientific Policy Review Subcommittee to review and prioritise its future work, Harnden was included in this special committee. The areas that were highlighted by this committee also indicated the personal interest of the committee members who undertook the review. Moreover, Harnden was appointed as the Chairman of the Editorial Board of the British Journal of Cancer in 1984, as well as, the Chairman of the Education Committee in 1987.

Nobel Prize winners' influence

Prestigious awards such as Nobel Prize facilitated the work of scientists by getting life-long support and facilities for their research. Their scientific and academic success helped them gaining more support and power by being promoted and offered leadership positions. In this regards, such leaders are influential primarily because of their scientific background and success. However, their main interest were mainly in science rather than administrative or management positions. During the review period three scientists won Nobel Prize. Their cases are briefly discussed including the impact of this award on their influence.

Frederick Sanger

Frederick Sanger was awarded the Nobel Prize twice for chemistry; in 1958 (he was a member of the MRC's external scientific staff) for his work on analysing the amino acid sequences of proteins and hence the structure of insulin and in 1980 for his contributions concerning the determination of base sequences in nucleic acids.

In an interview in 2001, Sanger spoke about the challenge of winning two Nobel Prizes:

"It's much more difficult to get the first prize than to get the second one,....because if you've already got a prize, then you can get facilities for work, and you can get collaborators, and everything is much easier."(*Interview with Frederick Sanger - Media Player at Nobelprize.org', n.d.*) .

The MRC provided him with all the facilities he needed and thus he did not need to apply for grants. This support helped him to achieve further succeed in his research career by wining another Nobel Prize. He preferred to do science and was not keen on administrative side of research. However, after winning the first prize, he transferred to the Laboratory of Molecular Biology, at University of Cambridge, as Head of the Division of Protein and Nucleic Acid Chemistry in 1962 and continued until his retirement in 1983.

Aaron Klug

Aaron Klug won the 1982 Nobel Prize for chemistry for his contributions to the knowledge of biological structures and to methods used for determining them, particularly electron microscopy and X-ray diffraction. He was appointed Director of the MRC's Laboratory of Molecular Biology in Cambridge from 1986 to 1996, and became a member of the council. His strategy of success was, once a scientist had solved key issues of a new scientific problem, and then he/she should move to another new problem. He also acknowledged the importance of working in a well-resourced institution and the benefit of collaborative work for scientific discoveries ('Interview with Aaron Klug - Media Player at Nobelprize.org', n.d.).

Cesar Milstein

Cesar Milstein won the Nobel Prize for Medicine in 1984 for his co-invention of a technique to produce unlimited quantities of pure monoclonal antibodies. He was in a leadership position before his winning of Nobel Prize as a joint head of the Division of Protein and Nucleic Acid Chemistry of the MRC Laboratory of Molecular Biology from 1981 to 1993 and later a deputy director of the MRC Laboratory of Molecular Biology.